WANG

STATISTICS/ENGINEERING GENERAL PROGRAM LIBRARY GLBR 22A

SYSTEM 2200

VS. 01-2200.01 A-00 FI-1-0

2200 General Library Statistics/Engineering

GLBR 22A

WANG LABORATORIES, INC.
836 NORTH STREET, TEWKSBURY, MASSACHUSETTS 01876, TEL.(617) 851-4111, TWX 710 343-6739, TELEX 94-7421

Warranty Disclaimer and Consequential Damages

The programming staff of Wang Laboratories, Inc. has taken due care to prepare this program package, including research, development, and testing to ascertain its effectiveness. Wang Laboratories, Inc. and its subsidiaries make no expressed or implied warranty of any kind with regard to this program package and its related material. In no event shall Wang Laboratories, Inc. or its subsidiaries be liable for incidental or consequential damages in connection with or arising out of the furnishing, performance or use of any of its programs.

Proprietary Rights

This program package is a company proprietary item. Tape cassettes of programs may not be reproduced without the written consent of Wang Laboratories, Inc.

Payment Address

The fee for a package is to be remitted directly to Wang Laboratories, Inc. at 836 North Street, Tewksbury, Massachusetts 01876. No agent or representative is charged with the authority to accept payment on behalf of the administrative offices of Wang, Laboratories, Inc.

INTRODUCTION

Programs of varying complexity and from different fields have been included in this library to provide a sample of the usefulness and versatility of the 2200 series calculators. Programs have been selected bearing in mind their use and possible application. Each one contains a set of instructions which is easy to follow; at least one example per program has been given to facilitate checking and enhance comprehension.

In loading the program tapes advantage may be taken of SKIP and BACKSPACE features. These two features and their use are explained on a following page.

Programs are designed to display all output on the CRT. However, they may be adapted for printing the output on either the 2201 (typewriter) or the 2221 (Hi-Speed Printer).

NOTE: All operating instructions assume you are at the beginning of the block you desire.

If you wish to load programs that are separated by other blocks, you may use one of two methods.

(1) LOAD each block until you reach the desired block. This would require the repetition of 4 keystrokes for each block between your current position and your desired position. The 4 keystrokes would be:

[CLEAR] , [CR/LF] , [LOAD] , [CR/LF]

This method would require you to REWIND the tape if you desire a block which you have passed.

(2) Using the SKIP feature will allow you to go from one block to another with less work, and the BACKSPACE feature will allow you to "back-up" to a block that you have passed.

a) SKIP - Subtract from the Block # corresponding to where you wish to be, the Block # corresponding to your current location then subtract 1. This is the # of files to skip to place you at the beginning of the desired block.

For Example,

The last block loaded was 4; you wish to load Block 12.

12 - 4 - 1 = 7

Key S, K, I, P, 7, F, [CR/LF]

b) BACKSPACE - Subtract from the block # corresponding to your present location, the block # corresponding to your desired location then add 1. This is the # of files to backspace to place you at the beginning of the desired block.

For Example,

The last block loaded was 12; you wish to load block 4,

12 - 4 + 1 = 9

Key B, A, C, K, S, P, A, C, E, 9, F, [CR/LF]

To change output device from 2216 (CRT display) to 2201 (typewriter) or 2221 (Hi-Speed Printer) the following procedure is used:

1. Choose what output is to be displayed or typed.

2. Insert a statement with the following information:
   For CRT display
   ```
   Statement #  SELECT  PRINT  005
   ```
   For Typewriter (2201)
   ```
   Statement #  SELECT  PRINT  211
   ```
   For Hi-Speed Printer (2221)
   ```
   Statement #  SELECT  PRINT  215
   ```

It may be advisable to change print to the CRT at the end of the program.

This page intentionally left blank

TABLE OF CONTENTS

Tape II

REGRESSION

This page intentionally left blank

WANG 2200 SERIES PROGRAM

LINEAR REGRESSION: Y = A + BX

TITLE

PS. 01-2200. 01A-00FI-1-0 — 6/1/73

NUMBER — DATE

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Fits the curve Y = A + BX to a set of N data points by the method of least squares. Also, an analysis of regression is performed.

BLOCK	SAVE "NAME"	BYTES REQUIRED
1		1159

PROGRAM DESCRIPTION

Fits the curve Y = A + BX to a set of N data points by the method of least squares. Also, an analysis of regression is performed - the regression table, F-value, coefficient of determination, coefficient of correlation, and standard error of estimate are printed out. The user may estimate values of Y from the regression curve by inputing values of X.

Sample correlation coefficient, $r = \dfrac{n\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{\left[n\Sigma x^2 - (\Sigma x)^2\right]\left[n\Sigma Y^2 - (\Sigma Y)^2\right]}}$

$$B = \frac{n\Sigma XY - (\Sigma X)(\Sigma Y)}{n\Sigma X^2 - (\Sigma X)^2}$$

$$A = \frac{\Sigma Y - B\Sigma X}{n}$$

Standard error of estimate, $\hat{S}_{Y \cdot X} = \dfrac{1}{n}\sqrt{(n\Sigma Y^2 - (\Sigma Y)^2) - \dfrac{(n\Sigma XY - \Sigma X\Sigma Y)^2}{n\Sigma X^2 - (\Sigma X)^2}}$

F-test for r, $F_r = \dfrac{r^2 (n-2)}{1 - r^2}$

Coefficient of Determination = r^2

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right.

OPERATING INSTRUCTIONS

EXAMPLE

Perform a linear regression on the following data points

X	Y
1	1
3	2
4	4
6	4
8	5
9	7
11	8
14	9

1. Key [RESET] [CLEAR] [CR/LF]
   [LOAD] [CR/LF]

2. Key [RUN] [CR/LF]

3. INSTRUCTION — INPUT N

4. Key # of Data Pairs [CR/LF]

4. Key 8 [CR/LF]

5. INSTRUCTION — INPUT DATA POINTS

6. Key X_1 , Y_1 [CR/LF]
   Key X_2 , Y_2 [CR/LF]
   .
   .
   .
   Key X_n , Y_n [CR/LF]

6. Key 1 , 1
   [CR/LF]
   Key 3 , 2
   [CR/LF]
   .
   .
   .
   Key 1 4 , 9
   [CR/LF]

7. Read Answer

   0 DEG COEFF, is A
   1 DEG COEFF. is B

0 DEG. COEFF. = .545454545455
1 DEG. COEFF. = .636363636363636

Program will stop, the word STOP will appear on the CRT (display)

To have residual table, and other results outputed, Key [CONTINUE] [CR/LF]

REGRESSION TABLE

SOURCE	SUM OF SQ.	DEG. FREEDOM	MEAN SQ.
REGRESSION	53.45454545454	1	53.45454545454
RESIDUAL	2.54545454546	6	.4242424242433
TOTAL	56	7	

F = 125.9999999997

COEFF. OF DETERMINATION = .9545454545454
COEFF. OF CORRELATION = .97700842092
STANDARD ERROR OF ESTIMATE = .65133894728

8. INSTRUCTION — DO YOU WISH TO ESTIMATE VALUES OF Y FROM THE REGRESSION CURVE? (1 = YES, 0 = NO)

9. Key either 1 or 0 [CR/LF] — 9. Key 1 [CR/LF]

   If you choose 0 go to Step 15.

10. INSTRUCTION — INPUT X

11. Key X [CR/LF] — 11. Key 5 [CR/LF]

12. Read Y — Y = 3.727272727273

13. INSTRUCTION — ANOTHER POINT? (1 = YES, 0 = NO)

14. Go to Step 9.

15. Program halts. — END PROGRAM

WANG 2200 SERIES PROGRAM

MULTIPLE LINEAR REGRESSION

TITLE

PS.01-2200.01A-00FI-2-0   6/1/73

NUMBER   DATE

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Fits the curve: $Y = B_0 + B_1X_1 + B_2X_2 + \ldots + B_mX_m$
to a set of N data points by the least squares method and then performs an analysis of regression. This last part is optional.

BLOCK	SAVE "NAME"	BYTES REQUIRED
2		2186

PROGRAM DESCRIPTION

This is a two-part program. The first segment fits the curve:

$$y = b_0 + b_1 X_1 + b_2 X_2 + \ldots + b_M X_M \qquad (M \leq 4)$$

to a set of N data points by the method of least squares. The second segment performs an analysis of regression - the regression table, F-value, coefficient of determination, coefficient of multiple correlation, and standard error of estimate are printed out. The user may also estimate values of Y from the regression curve by supplying values for the independent variables ($X_1, X_2, \ldots, X_M$).

Ref. 1: Roscoe, John T., "Fundamental Research Statistics", Holt, Rinehart and Winston, Inc. 1969, p. 264 ff.

Formulae

Solution matrix

$$\begin{array}{lllll}
nb_0 + & \Sigma X_1 b_1 & + \Sigma X_2 b_2 & + \ldots + \Sigma X_N b_N & = \Sigma Y \\
\Sigma X_1 b_0 + & \Sigma X_1^2 b_1 & + \Sigma X_1 X_2 b_2 & + \ldots + \Sigma X_1 X_N b_N & = \Sigma X, Y \\
 & \vdots & & & \\
\Sigma X_N b_0 + & \Sigma X_1 X_N b_1 & + \Sigma X_2 X_N b_2 & + \ldots + \Sigma X_N^2 b_N & = \Sigma X_N Y
\end{array}$$

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS

EXAMPLE

Given the following data

Y	2	5	7	8	5
X_1	8	8	6	5	3
X_2	0	1	1	3	4

fit a regression equation of the form

$$Y = b_0 + b_1X_1 + b_2X_2$$

Calculate Y for X1 = 2, X2 = 4.

1. Key [RESET] [CLEAR] [CR/LF]
   [LOAD] [CR/LF]
2. Key [RUN] [CR/LF]
3. INSTRUCTION

   INPUT M, N
   ?
4. Key # of Independent Variables , # of Data Points, [CR/LF]

   4. Key 2 , 5 [CR/LF]
5. INSTRUCTION

   INPUT DATA POINTS

   POINT 1

Each data point (X_1, X_2, . . ., X_N, Y) is inputed in one line. Each element of the data point is separated from the others by a comma. For example,

If M< 4:

Key X_1 , X_2 , Y [CR/LF] [CR/LF]

If M = 4:

Key X_1 , X_2 , X_3 , X_4 , Y [CR/LF]

OPERATING INSTRUCTIONS (Cont)

6. Key X_1 , X_2 , . . . X_M , Y [CR/LF] , [CR/LF]

or

Key X_1 , X_2 , X_3 , X_4 , Y [CR/LF]

6. Key 8 , 0 , 2 [CR/LF] [CR/LF]

7. INSTRUCTION

Continue as described in Step 6, until all data points have been entered.

POINT 2

8. Read Output

B(0) = 4.488188976374
B(1) = -3.93700787E-02
B(2) = .6377952755911

9. Program will STOP, to continue

Key [CONTINUE] [CR/LF]

10. Read Output

```
                        REGRESSION TABLE
SOURCE              SUM OF SQ.         DEG. FREEDOM        MEAN SQ.
REGRESSION           5.074015748031     2                   2.537007874016
RESIDUAL             16.12598425197     2                   8.062992125985
TOTAL                21.2               4
F= .3146484375
COEFF.  OF DETERMINATION= .2393403654732
COEFF.  OF MULTIPLE CORRELATION= .4892242486
STANDAD EROR OF ESTIMATE= 2.8395408301
DO YOU WISH TO ESTIMATE VALUES OF Y FROM THE
REGRESSION CURVE? (1=YES, 0=NO)
COORDINATE X 1
COORDINATE X 2
Y= 6.960629921259
ANOTHER POINT?
```

11. INSTRUCTION

DO YOU WISH TO ESTIMATE VALUES OF Y FROM THE REGRESSION CURVE?
(1 = YES, 0 = NO)
?

OPERATING INSTRUCTIONS (Cont)

12.	Key 1 or 0 [CR/LF]	12. Key 1 [CR/LF]
	If you keyed 0, then go to Step 19.	
13.	INSTRUCTION	COORDINATE X1
14.	Key X1 [CR/LF]	14. Key 2 [CR/LF]
15.	INSTRUCTION	COORDINATE X2
	Continue as in Step 14, until all coordinates have been entered.	
16.	Read Answer	Y = 6.96062992159
17.	INSTRUCTION	ANOTHER POINT?
18.	Go to Step 12.	
19.	Program Ends	END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

Nth ORDER REGRESSION

TITLE

PS.01-2200.01A-00FI-3-0 — 6/1/73

NUMBER — DATE

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Fits the curve: $Y = B_0 + B_1X + B_2X^2 + . . . + B_mX^m$
to a set of N(X,Y)- data points by the least squares method and then performs an analysis of regression. This last part is optional.

BLOCK	SAVE "NAME"	BYTES REQUIRED
3		2233

PROGRAM DESCRIPTION

This is a two-part program. The first segment fits the curve:

$$Y = b_0 + b_1 X + b_2 X^2 + \ldots + b_M X^M$$

to a set of N(X, Y) data points by the method of least squares. The second segment performs an analysis of regression - the regression table, F-value, coefficient of determination, coefficient of correlation, and standard error of estimate are printed out. The user may also estimate values of Y from the regression curve by supplying values for x. ($M \leq 6$)

Ref. 1: Kuo, Shan S. "Numerical Methods and Computers", Addison-Wesley, 1965, p. 219 ff.

Ref. 2: Roscoe, John T., "Fundamental Research Statistics", Holt, Rinehart and Winston, Inc., 1969, p. 264 ff.

Formulae

$b_0, b_1, \ldots, b_M$ are the solutions of the following equations

$$
\begin{aligned}
mb_0 &+ (\Sigma X)b_1 &+ \ldots + (\Sigma X^M)b_M &= \Sigma Y \\
(\Sigma X)b_0 &+ (\Sigma X^2)b_1 &+ \ldots + (\Sigma X^{M+1})\, b_M &= \Sigma XY \\
&\vdots \\
(\Sigma X^M)b_0 &+ (\Sigma X^{M+1})b_1 &+ \ldots + (\Sigma X^{2M})\, b_M &= \Sigma X^M Y
\end{aligned}
$$

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Given the following data

X	0	1	2	3	4	5	6	7	8	9
Y	9.1	7.3	3.2	4.6	4.8	2.9	5.7	7.1	8.8	10.2

fit the curve

$$Y = b_0 + b_1 X + b_2 X^2$$

and estimate Y at X = 2.

1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]
2. Key [RUN] [CR/LF]
3. INSTRUCTION — INPUT M, N
4. Key M , N [CR/LF] — 4. Key 2 , 1 0 [CR/LF]
5. INSTRUCTION — INPUT DATA POINTS

> NOTE: 0 raised to the 0 power will result in an error, therefore if X = 0 use X = .0000001 or even some other very small # to approximate 0.

6. Key X_1 , Y_1 [CR/LF]
   Key X_2 , Y_2 [CR/LF]
   .
   .
   .
   Key X_N , Y_N [CR/LF]

   Key . 0 0 0 0 0 1 , 9 . 1 [CR/LF]
   Key 1 , 7 . 3 [CR/LF]
   Key 2 , 3 . 2 [CR/LF]
   Key 3 , 4 . 6 [CR/LF]
   .
   .
   .
   Key 9 , 1 0 . 2 [CR/LF]

7. Read Output

0 DEG. COEFF. = b_0	0 DEG. COEFF. = 8.698181952449
1 DEG. COEFF. = b_1	1 DEG. COEFF. = -2.34060611459
.	2 DEG. COEFF. = .2878787925126
.	
.	
M DEG. COEFF. = b_M	

OPERATING INSTRUCTIONS (Cont)

8. Program halts, to continue, Key

   [CONTINUE] [CR/LF]

9. Read Output

```
          REGRESSION TABLE
SOURCE               SUM OF SQ.        DEG. FREEDOM     MEAN SQ.
REGRESSION            48.92633145245   2                 24.46316572623
RESIDUAL              8.63466854755    7                 1.233524078221
TOTAL                 57.561           9
F= 19.8319320702
COEFF. OF DETERMINATION= .8499909913388
COEFF. OF CORRELATION= .92194956008
STANDARD ERROR OF ESTIMATE= 1.1106412914
DO YOU WISH TO ESTIMATE VALUES OF Y FROM
THE REGRESSION CURVE? (1=YES, 0=NO)
INPUT X
Y= 5.168485296849
ANOTHER POINT? (1=YES, 0=NO)
```

10. INSTRUCTION — DO YOU WISH TO ESTIMATE VALUES OF Y FROM THE REGRESSION CURVE? (1 = YES, 0 = NO)

11. Key 1 or 0 [CR/LF] — 11. Key 1 [CR/LF]

    If you Key 0, go to Step 17.

12. INSTRUCTION — INPUT X

13. Key X [CR/LF] — 13. Key 2 [CR/LF]

14. Read Answer — Y = 5.168484893319

15. INSTRUCTION — ANOTHER POINT? (1 = YES, 0 = NO)

16. Go to Step 11.

17. Program halts.

WANG 2200 SERIES PROGRAM

EXPONENTIAL REGRESSION: $Y = Ae^{BX}$

TITLE

PS.01-2200.01A-00FI-4-0 6/4/73

NUMBER DATE

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Fits the curve: $Y = Ae^{BX}$ to a set of N(X,Y) - data points by the least squares method and then performs an analysis of regression. This last part is optional.

BLOCK	SAVE "NAME"	BYTES REQUIRED
4		1147

PROGRAM DESCRIPTION

Fits the curve:

(1) $Y = Ae^{BX}$

to a set of N data points, $(X_1, Y_1), X_2, Y_2), \ldots, (X_N, Y_N)$.

The problem is reduced to linear regression by taking the log of both sides of equation (1):

$\log(Y) = \log(A) + BX$

and substituting $Y' = \log(Y)$ and $A' = \log(A)$:

(2) $Y' = A' + BX$

A linear regression (by the method of least squares) is performed to determine A' and B. Then, A is determined by:

$A = e^{A'}$

An analysis of regression is done on the linear regression - the regression table, F-value, coefficient of determination, coefficient of correlation, and standard error of estimate are printed out. The user may estimate values of Y from the exponential regression curve by inputing values of X.

Ref.: Roscoe, John T., "Fundamental Research Statistics", Holt, Rinehart and Winston, Inc., 1969, 1. 273 ff.

Formulae

$$B = \frac{n\Sigma (X_i LOG_e Y_i) - (\Sigma X_i)(\Sigma LOG_e Y_i)}{n\Sigma X_i^2 - (\Sigma X_i)^2}$$

$$A = \exp\left[\frac{1}{n}\left\{(\Sigma LOG_e Y_i) - b\,\Sigma X_i\right\}\right]$$

$$r = \frac{n\Sigma (X_i LOG_e Y_i) - (\Sigma X_i)(\Sigma LOG_e Y_i)}{\sqrt{\left\{n\Sigma X_i^2 - (\Sigma X_i)^2\right\}\left\{n\Sigma (LOG_e Y_i)^2 - (\Sigma LOG_e Y_i)^2\right\}}}$$

PROGRAM DESCRIPTION (Cont)

F-Test for r, $F = \frac{r^2 (n-2)}{1 - r^2}$

Coefficient of Determination = r^2

Standard error of estimate, $\hat{S}_{Y \cdot X} = \frac{1}{N}\sqrt{(n\Sigma(\text{LOG Y})^2 - (\Sigma \text{ LOG Y})^2 \frac{(n\Sigma X(\text{LOGY}) - \Sigma X \Sigma \text{LOGY})^2}{n\Sigma X^2 - (\Sigma X)^2}}$

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Given the following data X | Y 0 | .25 1 | 1.1 2 | 5 3 | 22.5 4 | 101 5 | 452 fit $Y = Ae^{BX}$ and estimate Y at X = 7.
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	INPUT N
4. Key # of data points [CR/LF]	4. Key 6 [CR/LF]
5. INSTRUCTION	INPUT DATA POINTS
6. Key X_1 , Y_1 [CR/LF] Key X_2 , Y_2 [CR/LF] . . . Key X_N , Y_N [CR/LF]	6. Key 0 , . 2 5 [CR/LF] Key 1 , 1 . 1 [CR/LF] . . . Key 5 , 4 5 2 [CR/LF]
7. Read Output	A = .247981950976 B = 1.501811174648
8. Program Halts. To continue, Key [CONTINUE] [CR/LF]	

OPERATING INSTRUCTIONS (Cont)

9. Read Output

```
                    REGRESSION TABLE
SOURCE               SUM OF SQ.         DEG. FREEDOM      MEAN SQ.
REGRESSION           39.47014407519     1                  39.47014407519
RESIDUAL             2.24468250E-04     4                  5.61170625E-05
TOTAL                39.47036854344     5
F= 703353.7094924
COEFF. OF DETERMINATION= .9999943129933
COEFF. OF CORRELATION= .9999971565
STANDARD ERROR OF ESTIMATE= 7.49113225E-03
DO YOU WISH TO ESTIMATE VALUES OF Y FROM
THE REGRESSION CURVE? (1=YES,0=NO)
INPUT X
Y= 9120.490903452
ANOTHER POINT? (1=YES,0=NO)
```

10.	INSTRUCTION	DO YOU WISH TO ESTIMATE VALUES OF Y FROM THE REGRESSION CURVE? (1 = YES, 0 = NO)
11.	Key 1 or 0 [CR/LF] If you key 0, go to Step 17.	11. Key 1 [CR/LF]
12.	INSTRUCTION	INPUT X
13.	Key X [CR/LF]	13. Key 7 [CR/LF]
14.	Read Answer	Y = 9120.490903452
15.	INSTRUCTION	ANOTHER POINT? (1 = YES, 0 = NO)
16.	Go to Step 11.	
17.	Program halts	END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

GEOMETRIC REGRESSION: $Y = AX^B$

TITLE

PS. 01-2200. 01A-00FI-5-0 | 6/1/73

NUMBER | DATE

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Fits the curve $Y = AX^B$ to a set of N data points, $(X_1, Y_1), (X_2, Y_2), \ldots, (X_N, Y_N)$.

BLOCK	SAVE "NAME"	BYTES REQUIRED
5		1155

PROGRAM DESCRIPTION

Fits the curve:

(1) $Y = AX^B$

to a set of N data points, $(X_1, Y_1), (X_2, Y_2), \ldots, (X_N, Y_N)$.

The problem is reduced to linear regression by taking the log of both sides of equation (1):

$$LOG(Y) = LOG(A) + B\, LOG(X)$$

and substituting $Y' = LOG(Y)$, $X' = LOG(X)$, and $A' = LOG(A)$:

(2) $Y' = A' + BX'$

A linear regression (by the method of least squares) is performed to determine A' and B. Then, A is determined by:

$$A = e^{A'}$$

An analysis of regression is done on the linear regression - the regression table, F-value, coefficient of determination, coefficient of correlation, and standard error of estimate are printed out. The user may also estimate values of Y from the geometric regression curve by inputing values of X.

Ref.: Roscoe, John T., "Fundamental Research Statistics", Holt, Rinehart and Winston, Inc., 1969, p. 273 ff.

Formulae

$$B = \frac{n\Sigma\,(LOG_e X_i LOG_e Y_i) - (\Sigma\, LOG_e X_i)\,(\Sigma\, LOG_e Y_i)}{n\Sigma\,(LOG_e X_i)^2 - (\Sigma\, LOG_e X_i)^2}$$

$$A = \exp\left[\frac{1}{n}\left\{\Sigma\, LOG_e Y_i) - (2\, LOG_e X_i)b\right\}\right]$$

$$r = \frac{n\Sigma\,(LOG_e X_i\, LOG_e Y_i) - (\Sigma\, LOG_e X_i)\,(\Sigma\, LOG_e Y_i)}{\sqrt{n\Sigma\,(LOG_e X_i)^2 - (\Sigma\, LOG_e X_i)^2 \quad n\Sigma\,(LOG_e Y_i)^2 - (\Sigma\, LOG_e Y_i)^2}}$$

PROGRAM DESCRIPTION (Cont)

Standard Error of Estimate $\hat{S}_{Y \cdot X}$

$$\frac{1}{n}\sqrt{\left[n\Sigma(\text{LOG } Y)^2 - (\Sigma \text{ LOG } Y)^2\right] - \frac{(n\Sigma\ (\text{LOG } X)\ (\text{LOG } Y) - \Sigma \text{ LOG } Y\ \Sigma \text{ LOG } X)^2}{n\Sigma\ (\text{LOG } X)^2 - (\Sigma \text{ LOG } X)^2}}$$

F test for r, $F_r = \frac{r^2 (n-2)}{1 - r^2}$

Coeff. of determination $= r^2$

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right.

OPERATING INSTRUCTIONS	EXAMPLE
	Given the following data

X	1	2	3	4	5	6	7	8
Y	.5	2	5	8	12	18	25	32

fit $Y = AX^B$ and estimate Y when X = 2.5.

1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]

2. Key [RUN] [CR/LF]

3. INSTRUCTION — INPUT N
?

4. Key # of data pairs [CR/LF] — 4. Key 8 [CR/LF]

5. INSTRUCTION — INPUT DATA POINTS

> Since $LOG_e(0)$ is undefined, you must approximate 0 by a near zero value, such as .0000001.

6. Key X_1 , Y_1 [CR/LF] — 6. Key 1 , . 5 [CR/LF]

Key X_2 , Y_2 [CR/LF] — Key 2 , 2 [CR/LF]

.
.
.

Key X_N , Y_N [CR/LF] — Key 8 , 3 2 [CR/LF]

7. Read output — A = .509786 3625245
B = 1.99336 8171127

8. Program halts. To continue
Key [CONTINUE] [CR/LF]

9. Read Output

```
                     REGRESSION TABLE
SOURCE                SUM OF SQ.       DEG. FREEDOM      MEAN SQ.
REGRESSION             13.76167701101   1                 13.76167701101
RESIDUAL               1.21254695E-02   6                 2.02091158E-03
TOTAL                  13.77380248054   7
F= 6809.63832879
COEFF. OF DETERMINATION= .9991196715978
COEFF. OF CORRELATION= .99955973888
STANDARD ERROR OF ESTIMATE= 4.49545502E-02
DO YOU WISH TO ESTIMATE VALUES OF Y FROM
THE REGRESSION CURVE? (1=YES,0=NO)
INPUT X
Y= 3.166862158769
ANOTHER POINT? (1=YES,0=NO)
```

10. INSTRUCTION — DO YOU WISH TO ESTIMATE VALUES OF Y FROM THE REGRESSION CURVE? (1 = YES, 0 = NO)

11. Key 1 or 0 [CR/LF] — 11. Key 1 [CR/LF]

If you key 0, go to Step 17.

12. INSTRUCTION — INPUT X

13. Key X [CR/LF] — 13. Key 2 . 5 [CR/LF]

14. Read Answer — Y = 3.166862158769

15. INSTRUCTION — ANOTHER POINT? (1 = YES, 0 = NO)

16. Go to Step 11.

17. Program halts. — END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

LINEAR CORRELATION

TITLE

PS. 01-2200. 01A-00FI-6-0 — 6/1/73

NUMBER — **DATE**

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Computes the coefficient of linear correlation, R, between 2 variables, X and Y.

BLOCK	SAVE "NAME"	BYTES REQUIRED
6		454

PROGRAM DESCRIPTION

Computes the coefficient of linear correlation, R, between 2 variables, X and Y, by the equation:

$$R = \frac{N\Sigma (X_i Y_i) - (\Sigma X_i)(\Sigma Y_i)}{\sqrt{(N\Sigma X_i^2 - (\Sigma X_i)^2)(N\Sigma Y_i^2 - (\Sigma Y_i)^2)}}$$

where

N = number of observations

$(X_1, X_2), \ldots, (X_N, Y_N)$ are the data points.

The degree of linear correlation varies from no linear correlation (R = 0) to perfect linear correlation (R = ±1).

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS

EXAMPLE

Given the following data

X	Y
0	.25
1	1.1
2	5
3	22.5
4	101
5	452

determine the coeff. of correlation.

1. Key [RESET] [CLEAR] [CR/LF]
   [LOAD] [CR/LF]

2. Key [RUN] [CR/LF]

3. INSTRUCTION — NO. OF DATA POINTS, N?

4. Key # of data points [CR/LF] — 4. Key 6 [CR/LF]

5. INSTRUCTION — INPUT DATA POINTS 1/LINE (XI, YI, CARRIAGE RETURN)

6. Key X_1 , Y_1 [CR/LF] — 6. Key 0 , . 2 5 [CR/LF]
   Key X_2 , Y_2 [CR/LF] — Key 1 , 1 . 1 [CR/LF]
   .
   .
   .
   Key X_N , Y_N [CR/LF] — Key 5 , 4 5 2 [CR/LF]

7. Read Answer — COEFF. OF CORRELATION = .7730712833711

END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

CORRELATION MATRIX
TITLE

PS.01-2200.01A-00FI-7-0 — **NUMBER**
6/1/73 — **DATE**

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Given a set of N observations in M variables, the correlation coefficient between each pair of variables is computed.

BLOCK	SAVE "NAME"	BYTES REQUIRED
7		1596

PROGRAM DESCRIPTION

Given a set of N observations in M variables, the correlation coefficient between each pair of variables is computed. The observations should be arranged in the following format: $(M \leq 9)$

VARIABLES

OBSERVATIONS	V_1	V_2	V_3	. . .	V_M
1	1.2	1.4			
2	3.0	3.6			
3					
.					
.					
.					
N					

The correlation matrix is an array of correlation coefficients where the element in the ith row and jth column of the matrix is the correlation coefficient between the ith and jth variables. The correlation matrix is printed out row by row skipping a line between each row; each row is printed out from left to right using as many lines as required.

Ref.: Roscoe, John T., "Fundamental Research Statistics", Holt, Rinehart and Winston, Inc. 1969, p. 80.

Formula

$$r_{I,J} = \frac{N * \Sigma X_I X_J - \Sigma X_I \Sigma X_J}{\sqrt{(N\Sigma X_I^2 - (\Sigma X_I)^2)(N\Sigma X_J^2 - (\Sigma X_J)^2}}$$

$r_{I,J}$ is the coefficient of correlation between Col. I and Row J.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right.

OPERATING INSTRUCTIONS

EXAMPLE

VARIABLES

OBSERVATIONS	V_1	V_2	V_3	V_4	V_5	V_6
1	1	2	3	4	5	6
2	2	4	6	8	10	12
3	1	1	2	2	3	3
4	10	20	30	40	50	60
5	20	21	30	31	40	41
6	5	6	8	9	10	11
7	8	9	12	13	20	21
8	6	5	8	7	9	8

1. Key [RESET] [CLEAR] [CR/LF]
   [LOAD] [CR/LF]

2. Key [RUN] [CR/LF]

3. INSTRUCTION — INPUT N, M

4. Key # of OBS. , # of Variables, [CR/LF]

   4. Key 8 , 6 [CR/LF]

5. INSTRUCTION — INPUT MATRIX

> The matrix is inputed 1 row at a time, each element of a row being separated from the other by a comma. The end of a row is signaled by a [CR/LF] immediately following a ?.
>
> For example, a row (1, 2, 3, 4, 5) would be inputed as follows:
>
> :1, 2, 3, 4, 5 [CR/LF]
>
> ? [CR/LF]

6. Key Row 1 (separate each element by a comma) [CR/LF] [CR/LF]

   6. Key 1 , 2 , 3 , 4 , 5 , 6 [CR/LF] [CR/LF]

7. Continue as in Step 6 until all rows have been entered.

8. Read Output

CORRELATION MATRIX:

```
CORRELATION MATRIX:
 1             .9050304029759  .8889477287354  .7861654344404
 .8036271568616  .7330850411146
 .9050304029759  1             .9979403263559  .9736735293795
 .9784473407736  .9514482103872
 .8889477287354  .9979403263559  1             .9153849761381
 .9256854863732  .9049630407939
 .7861654344404  .9736735293795  .9153849761381  1
 .9964929192138  .9943204246135
 .8036271568616  .9784473407736  .9256854863732  .9964929192138
 1             .9937107479557
 .7330850411146  .9514482103872  .9049630407939  .9943204246135
```

VARIANCE ANALYSIS

BLOCK NO.	PROGRAM TITLE
8	ONE-WAY ANALYSIS OF VARIANCE
9	TWO-WAY ANALYSIS OF VARIANCE
10	ANALYSIS OF VARIANCE - LATIN SQUARES

This page intentionally left blank

WANG 2200 SERIES PROGRAM

ONE-WAY ANALYSIS OF VARIANCE
TITLE

PS. 01-2200.01A-00FI-8-0 — NUMBER

6/1/73 — DATE

2200A-01, 2215, 2216, 2217
EQUIPMENT

PROGRAM ABSTRACT

Performs a one-way analysis of variance on up to 99 groups of data.

BLOCK	SAVE "NAME"	BYTES REQUIRED
8		1565

PROGRAM DESCRIPTION

Performs a 1-way analysis of variance on up to 99 groups of data. The analysis of variance table and F-value are printed out.

Ref.: Roscoe, John T., "Fundamental Research Statistics", Holt, Rinehart and Winston, Inc., p. 230 ff.

Formulae

Suppose that we have independent random samples of sizes $n_1, n_2, \ldots, n_k$, from k populations and X_{ij} is the jth observation of ith population with

$$n_1 + n_2 + \ldots + n_k = n.$$

Suppose that X_{ij} are independently $N(\mu_i, \sigma^2)$, $i=1, \ldots, k$. and $X_{ij} = \mu_i + e_{ij}$

$$(i=1, \ldots k;\ j=1, \ldots n_i)$$

e_{ij} are independently $N(0, \sigma^2)$

Then the F-test for the null-hypothesis,

$$H_0;\ \mu_1 = \mu_2 = \ldots = \mu_k$$

can be written as:

$$F = \frac{SSB/k-1}{SSE/n-k} = \frac{A}{B} = \frac{n-k}{k-1} \frac{\left[\sum_{i=1}^{k} \frac{1}{n_i}\left(\sum_{j=1}^{n_i} X_i\right)^2 - \frac{1}{n}\left(\sum_{i=1}^{k}\sum_{j=1}^{n_i} x_{ij}\right)^2\right]}{\left[\sum_{i=1}^{k}\sum_{j=1}^{n_i} x_{ij}^2 - \sum_{i=1}^{k} \frac{1}{n_i}\left(\sum_{j=1}^{n_i} x_{ij}\right)^2\right]}$$

with k-1 and n-k degrees of freedom.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS

EXAMPLE

Given the following data, perform a 1-way analysis of variance

Group 1	Group 2	Group 3
2	3	3
4	4	5
5	2	3
3		2

1. Key [RESET] [CLEAR] [CR/LF]
   [LOAD] [CR/LF]

2. Key [RUN] [CR/LF]

3. INSTRUCTION — NO. OF GROUPS
   ?

4. Key # of Groups [CR/LF] — 4. Key 3 [CR/LF]

5. INSTRUCTION — NO. OF ELEMENTS IN GROUP 1
   ?

6. Key # of Elements in Group 1 [CR/LF] — 6. Key 4 [CR/LF]

7. INSTRUCTION — INPUT GROUP 1

Input the elements in the group when requested. The elements in the group are inputed 4/line. If necessary, add zeroes to the end of the group to complete the set of 4 elements. For example, the group 1, 2, 3, 4, 5, 6 is inputed in 2 steps as follows:

: 1, 2, 3, 4
: 5, 6, 0, 0

Note: Each element is separated by a comma.

OPERATING INSTRUCTIONS (Cont)

8. Key Group 1, 4/line [CR/LF]

Continue until entire group has been entered.

8. Key 2 , 4 , 5 , 3 [CR/LF]

9. Program will back to Step 5. The next group is asked for. This loop will continue until all groups have been entered.

10. Read Variance Table and F-value.

SOURCE	SUM OF SQ.	DEG. FREEDOM	MEAN SQ.
BETW. GROUPS	.4318181818	2	.2159090909
WITHIN GROUPS	11.75	8	1.46875
TOTAL	12.1818181818	10	

F= .1470019342298

11. Program Ends

END PROGRAM

WANG 2200 SERIES PROGRAM

TWO-WAY ANALYSIS OF VARIANCE
TITLE

PS. 01-2200. 01A-00FI-9-0	6/1/73
NUMBER	**DATE**

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Computes the analysis of variance table and the F-value for the row and column variance in a two-factor experiment.

BLOCK	SAVE "NAME"	BYTES REQUIRED
9		1652

PROGRAM DESCRIPTION

Computes the analysis of variance table and the F-values for the row and column variance in a two-factor experiment.

Ref.: Brunk, H. D., "An Introduction to Mathematical Statistics", Blaisdell Publishing Co., 1965, p. 296.

Formulae:

The analysis of variance table for the observations:

$$X_{ij} \quad [i = 1, 2, \ldots k; \quad j = 1, 2, \ldots, n]$$

where k = number of rows and n = number of columns is given below:

with $X_{i.} = \frac{1}{n} \sum_{j=1}^{n} X_{ij}$, $x._{j} = \frac{1}{k} \sum_{i=1}^{k} X_{ij}$ and $X.. = \frac{1}{nk} \sum_{i} \sum_{j} X_{ij}$;

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Between Rows	$SS_A = n \sum_i (X_{i.} - X..)^2$	k-1	$A = \frac{SS_A}{k-1}$	$F_A = \frac{A}{C}$
Between columns	$SS_B = k \sum_j (X_{.j} - X..)^2$	n-1	$B = \frac{SS_B}{n-1}$	$F_B = \frac{B}{C}$
Residual	$SS_e = \sum_i \sum_j (X_{ij} - X_{i.} - X_{.j} + X..)^2$	(k-1)(n-1)	$C = \frac{SS_e}{(k-1)(n-1)}$	
Total	$SS_t = \sum_i \sum_j (X_{ij} - X..)^2$	nk-1		

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS

1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]

2. Key [RUN] [CR/LF]

3. INSTRUCTION — NO. OF ROWS, NO. OF COLUMNS?
?

4. Key # of rows , # of cols. [CR/LF] — 4. Key 6 , 4 [CR/LF]

5. INSTRUCTION — INPUT TABLE OF DATA

It is assumed that the data is arranged in a table (see example). The data in the table is inputed, row by row, 4 elements/line. If necessary, attach zeroes to the end of each row to complete the set of 4 input elements. For example, the row 1, 2, 3, 4, 5 would be inputed in 2 steps as follows:

: 1, 2, 3, 4
: 5, 0, 0, 0

6. Key Row 1 [CR/LF] — 6. Key 2 7 8 , 2 7 3 , 2 8 5 , 3 8 5 [CR/LF]

7. Continue entering rows until all rows have been entered.

EXAMPLE

	A	B	C	D
I	278	273	285	385
II	306	288	310	395
III	277	227	349	368
IV	162	150	141	196
V	162	170	177	154
VI	249	225	227	263

8. Read Variance Table and F-value.

SOURCE	SUM OF SQ.	DEG. FREEDOM	MEAN SQ.
TOTAL	137492.958333	23	
COLUMN	16735.791666	3	5578.597222
ROW	106275.208333	5	21255.0416666
RESIDUAL	14481.958334	15	965.4638889333

F(COL)= 5.778152125569
F(ROW)= 22.01536682028

WANG 2200 SERIES PROGRAM

ANALYSIS OF VARIANCE - LATIN SQUARES
TITLE

PS. 01-2200. 01A-00FI-10-0 — 6/1/73
NUMBER — **DATE**

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Computes the analysis of variance table and the F-value for column, row and treatment variance for a simple Latin Square design.

BLOCK	SAVE "NAME"	BYTES REQUIRED
10		1184

PROGRAM DESCRIPTION

Computes the analysis of variance table and the F-values for column, row, and treatment variance for a simple Latin square design. The user must supply the matrix of treatment assignments and the matrix of data.

Ref.: Brunk, H.D., "Mathematical Statistics", Blaisdell Publishing Co., 1965, p. 301.

Formulae

The program requires that the matrix of treatment assignments be defined by data statements.

We shall denote the observations by $\{X_{ijk}\}$, where X_{ijk} is the observation on the treatment combination where factor A is at the ith level, B at the jth, C at the kth and the triples (i, j, k) take on only the m^2 values dictated by the particular Latin Square selected for the experiment. Then $\{X_{ijk}\}$ can be tabulated in the following fashion.

	1	2	3	. . .	j=m
1	X_{111}	X_{122}	X_{133}	. . .	X_{1mm}
2	X_{212}	X_{223}	X_{234}	. . .	X_{2m1}
.					
.	.				
.	.				
	.				
i=m	X_{m1m}	X_{m21}	X_{m32}		$X_{mm(m-1)}$

Let

$$\bar{X}_{i..} = \frac{1}{m} \sum_{j,k} X_{ijk}, \quad \bar{X}_{.j.} = \frac{1}{m} \sum_{i,k} X_{ijk}$$

$$\bar{X}_{..k} = \frac{1}{m} \sum_{ij} X_{ijk}, \quad \bar{X} = \frac{1}{m^2} \sum_{ijk} X_{ijk}$$

PROGRAM DESCRIPTION (Cont)

Note that there are only m terms in the sum $\sum_{j,k} X_{ijk}$, for there are only m pairs (j,k) corresponding to a fixed i.

Then, $SS_A = m \sum_i (\overline{X}_{i..} - \overline{X})^2$, $SS_B = m \sum_J (\overline{X}_{.j.} - \overline{X})^2$

$SS_C = m \sum (\overline{X}_{..k} - \overline{X})^2$, $SS_C = \sum_{i,j,k} (X_{ijk} - \overline{X}_{i..} - \overline{X}_{.j.} - \overline{X}_{..k} + 2\overline{X})^2$

$SS_t = \sum_{i,j,k} (X_{ijk} - \overline{X})^2$

Let $A = \frac{SS_A}{m-1}$, $B = \frac{SS_B}{m-1}$, $C = \frac{SS_C}{m-1}$, $E = \frac{SS_C}{(m-1)(m-2)}$,

Then, the analysis of variance table can be presented in the following fashion:

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F
Row	m-1	SS_A	A	$F_A = \frac{A}{E}$
Column	m-1	SS_B	B	$F_B = \frac{B}{E}$
Treatment	m-1	SS_C	C	$F_C = \frac{C}{E}$
Residual	(m-1) (m-2)	SS_e	E	
Total	$m^2 - 1$	SS_t		

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS

EXAMPLE

Matrix of treatment assignments:

$$\begin{pmatrix} 1 & 2 & 3 & 4 & 5 \\ 2 & 3 & 4 & 5 & 1 \\ 3 & 4 & 5 & 1 & 2 \\ 4 & 5 & 1 & 2 & 3 \\ 5 & 1 & 2 & 3 & 4 \end{pmatrix}$$

Matrix of data:

$$\begin{pmatrix} 40 & 50 & 30 & 40 & 40 \\ 50 & 55 & 35 & 50 & 55 \\ 40 & 60 & 40 & 50 & 45 \\ 35 & 40 & 30 & 35 & 30 \\ 55 & 60 & 45 & 45 & 60 \end{pmatrix}$$

1. Key [RESET] [CLEAR] [CR/LF]
   [LOAD] [CR/LF]

Enter N in data statement 500. Enter the matrix of treatment assignments row by row in data statements 501 to 998. For example, one might have for a 5 x 5 Latin Square: ($N \leq 9$)

```
500 DATA 5
501 DATA 1, 2, 3, 4, 5
502 DATA 2, 3, 4, 5, 1
503 DATA 3, 4, 5, 1, 2
504 DATA 4, 5, 1, 2, 3
505 DATA 5, 1, 2, 3, 4
```

Note: Please separate matrix elements with commas and no spaces.

2. Key 5 0 0 [DATA] N
3. Key 5 0 1 [DATA] $A_{1,1}$, $A_{1,2}$, . . . , $A_{1,N}$ [CR/LF]
   .
   .
   .
   Key 5 0 N [DATA] $A_{N,1}$, $A_{N,2}$, . . . , $A_{N,N}$ [CR/LF]

2. Key 5 0 0 [DATA] 5
3. Key 5 0 1 [DATA] 1 , 2 , 3 , 4 , 5 [CR/LF]
   .
   .
   .
   Key 5 0 5 [DATA] 5 , 1 , 2 , 3 , 4 [CR/LF]

OPERATING INSTRUCTIONS (Cont)

4. Key [RUN] [CR/LF]

5. INSTRUCTION — INPUT TABLE OF DATA

> The matrix of data is entered 1 row at a time. The elements of the row are separated by a comma. The end of a row is signaled by 2 [CR/LF].
> For example, row 1 is 1, 2, 3, 4, 5, 6 and is entered as follows:
>
> 1, 2, 3, 4, 5, 6, [CR/LF]
>
> ? [CR/LF]

6. Key Row 1 of data matrix, [CR/LF] [CR/LF] — 6. Key 4 0 , 5 0 , 3 0 , 4 0 , 4 0 [CR/LF] [CR/LF]

7. Continue until all rows have been entered.

8. Read Variance Table and F-values.

```
SOURCE          SUM OF SQ.      DEG. FREEDOM      MEAN SQ.
ROW              1146            4                 286.5
COLUMN           736             4                 184
TREATMENT        146             4                 36.5
RESIDUAL         168             12                14
TOTAL            2196            24
F(ROW)= 20.46428571429
F(COL)= 13.14285714286
F(TREAT)= 2.607142857143
```

This page intentionally left blank

STATISTICAL HYPOTHESIS TESTING

This page intentionally left blank

WANG 2200 SERIES PROGRAM

CHI-SQUARE TEST & DISTRIBUTION

TITLE

PS. 01-2200. 01A-00FI-11-0 — 6/1/73

NUMBER — DATE

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

The Chi-Square test compares an observed distribution with an assumed distribution.

BLOCK	SAVE "NAME"	BYTES REQUIRED
11		891

PROGRAM DESCRIPTION

The Chi-Square (X^2) test compares an observed distribution with an assumed distribution.

$$X^2 = \sum_{i=1}^{N} \frac{(O_i - E_i)^2}{E_i}$$

where:

O_i = observed frequency

E_i = expected frequency

N = number of observed values

The larger the deviations, the larger the value of X^2.

The Chi-Square distribution is a continuous distribution used primarily to check the "goodness of fit" of an assumed distribution when compared to observed frequencies. If V = degrees of freedom, the probability integral may be approximated by:

$$\text{V odd: } P(X^2, V) = \left(\frac{(X^2)^{\frac{V+1}{2}} e^{\frac{-X^2}{2}}}{V(V-2)\ldots 1} \right) \left(\frac{2}{X^2} \right)^{\frac{1}{2}} \left(1 + \sum_{R=1}^{\infty} \frac{(X^2)^R}{(V+2)\ldots(V+2R)} \right)$$

$$\text{V even: } P(X^2, V) = \left(\frac{(X^2)^{\frac{V}{2}} e^{\frac{-X^2}{2}}}{V(V-2)\ldots 2)} \right) \left(1 + \sum_{R=1}^{\infty} \frac{(X^2)^R}{(V+2)\ldots(V+2R)} \right)$$

Precision should be to about 10^{-5}.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right.

OPERATING INSTRUCTIONS

EXAMPLE

OBS	EXP
14	10
9	10
7	10
13	10
6	10
11	10

Find X^2, $P(X^2, 6-1)$

1. Key [RESET] [CLEAR] [CR/LF]
   [LOAD] [CR/LF]

2. Key [RUN] [CR/LF]

3. INSTRUCTION — TO COMPUTE X ▲ 2 INPUT 0, TO COMPUTE P(X ▲ 2, V) INPUT 1

4. Key 0 [CR/LF] — 4. Key 0 [CR/LF]

   or

   Key 1 [CR/LF]

> If you keyed 0, then go to Step 5. Otherwise go to Step 13.

5. INSTRUCTION — NO. OF OBSERVED VALUES?

6. Key # of OBS. Values [CR/LF] — 6. Key 6 [CR/LF]

7. INSTRUCTION — INPUT OBSERVED VALUES

> The observed and expected values are inputed as follows:
>
> 0_1, E_1 [CR/LF]
>
> 0_2, E_2 [CR/LF]

OPERATING INSTRUCTIONS (Cont)

8.	Key O_1 , E_1 [CR/LF] . . . Key O_N , E_N [CR/LF]	8.	Key 1 4 , 1 0 [CR/LF] Key 9 , 1 0 [CR/LF] Key 7 , 1 0 [CR/LF] Key 1 3 , 1 0 [CR/LF] Key 6 , 1 0 [CR/LF] Key 1 1 , 1 0 [CR/LF]
9.	Read		CHI-SQUARE = 5.2 P(5.2, 5) = .6080355905271
10.	INSTRUCTION		MORE INPUT? (1 = YES, 0 = NO)
11.	Key 1 [CR/LF] if you have more input Key 0 [CR/LF] if you have no more input. Program halts.	11.	Key 1 [CR/LF]
12.	Go to Step 3.		
13.	INSTRUCTION		DEGREES OF FREEDOM?
14.	Key Deg. of Freedom [CR/LF]		
15.	INSTRUCTION		CHI-SQUARE?
16.	Key X^2 [CR/LF]		
17.	Read		
18.	Go to Step 10.		

WANG 2200 SERIES PROGRAM

CHI-SQUARE ANALYSIS

TITLE

PS. 01-2200. 01A-00FI-12-0 — 6/1/73

NUMBER — **DATE**

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Computes for an N x M contingency table, the value of CHI-SQUARE.

BLOCK	SAVE "NAME"	BYTES REQUIRED
12		1683

PROGRAM DESCRIPTION

Computes, for an N x M contingency table, the value of Chi-Square, the number of degrees of freedom, the expected value for each cell and the Chi-Square contribution from each cell.

N times M must be $\leq$ 50 and must be a multiple of 4.

FORMULAE

Expected Value for Each Cell

The expected value for cell (I, J) is the sum of the observed values of Row I times the sum of the observed values of column J divided by the total observed values.

$$E_{1,1} = \sum_{J=1}^{m} O_{1,J} * \sum_{I=1}^{N} O_{I,1} \div \sum_{I=1}^{N} \sum_{J=1}^{M} O_{I,J}$$

Chi-Square Contribution for Each Cell

$$X^2 = \frac{(O - E)^2}{E}$$

Chi-Square = Σ of the individual contributions

Degrees of Freedom

(# of Rows - 1) (# of Columns - 1)

OPERATING INSTRUCTIONS

EXAMPLE

	I	II	III
A	160	242	37
B	108	178	18

1. Key [RESET] [CLEAR] [CR/LF]
   [LOAD] [CR/LF]

2. Key [RUN] [CR/LF]

3. INSTRUCTION — NUMBER OF ROWS?

4. Key No. of Rows [CR/LF] — 4. Key 2 [CR/LF]

5. INSTRUCTION — NUMBER OF COLUMNS?

6. Key No. of Cols. [CR/LF] — 6. Key 3 [CR/LF]

7. INSTRUCTIONS — INPUT CONTINGENCY TABLE
   4 ELEMENTS/LINE

The elements of the contingency table are entered row by row 4 elements/line. If the last elements to be inputed in a row do not make a set of 4, complete the set of 4 with the first elements in the next row. If it is the last row, complete it with zeroes. For example,

1	2	3
4	5	6
7	8	9

is inputed as follows:

: 1, 2, 3, 4
: 5, 6, 7, 8
: 9, 0, 0, 0

8. Key ELEMENT ROW BY ROW 4 ELEMENTS/LINE [CR/LF]

8. Key 1 6 0 , 2 4 2 , 3 7 , 1 0 8 [CR/LF]
   Key 1 7 8 , 1 8 , 0 , 0 [CR/LF]

The expected value for each cell and its Chi-Square contribution is calculated and printed. Also the total Chi-Square is printed and the # of degrees of freedom.

9. Read Table

OBSERVED VALUE	FOR EACH CELL EXPECTED VALUE	CHI 2 CONTRIBUTION
	COLUMN 1	
160	158.34724	1.7250775E-2
108	109.65276	2.4911481E-2
	COLUMN 2	
242	248.15612	.15271781
178	171.84388	.22053658
	COLUMN 3	
37	32.496635	.62407366
18	22.503365	.90121163

CHI-SQUARE = 1.9407019

DEGREES OF FREEDOM = 2

WANG 2200 SERIES PROGRAM

T-TEST

TITLE

PS. 01-2200. 01A-00FI-13-0	6/1/73
NUMBER	**DATE**
2200A-01, 2215, 2216/2217	
EQUIPMENT	

PROGRAM ABSTRACT

Calculates the T-statistic to test whether or not two samples have the same population mean.

BLOCK	SAVE "NAME"	BYTES REQUIRED
13		1428

PROGRAM DESCRIPTION

Calculates the t-statistic to test whether or not two samples have the same population means. The test is performed for one of the four following hypotheses.

Let μ_i = population mean for sample i.

σ_i = standard deviation for sample i.

Hypothesis 1: $\mu_1 = K$; K = a given value.

Hypothesis 2: $\mu_1 = \mu_2$; $\sigma_1 = \sigma_2$

Hypothesis 3: $\mu_1 = \mu_2$; $\sigma_1 \neq \sigma_2$

Hypothesis 4: $\mu_1 = \mu_2$; where samples 1 and 2 are paired variates.

Sample 1: $X_1, X_2, \ldots, X_n$; N = no. of elements in sample 1.

Sample 2: $Y_1, Y_2, \ldots, Y_m$; M = no. of elements in sample 2.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right.

OPERATING INSTRUCTIONS

EXAMPLE

Hypotheses 4: $\mu_1 = \mu_2$

12 pairs of elements

Sample	
2.9	5.8
3.4	4.9
3	2.3
3.4	2.1
3.7	2.6
4	3.8
2.9	7.9
3.1	4
2.8	4.1
2.8	3.8
2.4	3.3
3	3.1

Find T and Degrees of freedom

1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]
2. Key [RUN] [CR/LF]
3. INSTRUCTION — HYPOTHESIS TO BE TESTED?
4. Key HYPOTHESIS CODE [CR/LF] — 4. Key 4 [CR/LF]

If Hypothesis is #4, go to Step 12.

5. INSTRUCTION — NO. OF ELEMENTS IN SAMPLE I
6. Key NO. OF ELEMENTS IN SAMPLE 1 [CR/LF]
7. INSTRUCTION — ENTER SAMPLE I

> Sample is inputed 4 elements/line completing the last input line with zeroes if necessary. For example, the sample 1, 2, 3, 4, 5, 6 would be inputed in 2 steps as follows:
>
> 1, 2, 3, 4
> 5, 6, 0, 0
>
> Please note: each element of an input line is separated by a comma.

8. Key ELEMENTS OF SAMPLE I (4 ELEMENTS/LINE)
   [CR/LF]

> If hypothesis tested is 2 or 3, then go to Step 16.

9. INSTRUCTION	ENTER GIVEN VALUE OF MEAN
10. Key VALUE OF MEAN [CR/LF]	
11. Go to Step 16.	
12. INSTRUCTION	NO. OF PAIRS OF ELEMENTS?
13. Key NO. OF PAIRS OF ELEMENTS [CR/LF]	13. Key 1 2 [CR/LF]
14. INSTRUCTION	ENTER SAMPLES (1 PAIRS/LINE)

> The samples are inputed one pair of data/input line. That is,
>
> X_1, Y_1
> X_2, Y_2
> $\vdots$
> X_N, Y_N
>
> Note: The pairs are separated by a comma.
>
> N = No. of pairs of elements.

OPERATING INSTRUCTIONS (Cont)

15. Key $\underline{X_1}$, $\underline{Y_1}$ [CR/LF]

.
.
.

Key $\underline{X_N}$, $\underline{Y_N}$ [CR/LF]

16. Read

15. Key 2 . 9 , 5 . 8 [CR/LF]

.
.
.

Key 3 , 3 . 1 [CR/LF]

T VALUE = 1.677252659013

DEG. FREEDOM = 11

END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

WILCOXON MATCHED-PAIRS SIGNED-RANK TESTS
TITLE

PS. 01-2200. 01A-00FI-14-0 — 6/1/73
NUMBER — **DATE**

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Performs the Wilcoxon matched-pairs signed-ranks test on a set of N pairs of data.

BLOCK	SAVE "NAME"	BYTES REQUIRED
14		1720

PROGRAM DESCRIPTION

Performs the Wilcoxon matched-pairs signed-ranks test on a set of N pairs of data. Note: It is best to leave tie scores for a given pair out of the analysis. ($N \leq 130$).

Ref.: Roscoe, John T., "Fundamental Research Statistics", Holt, Rinehart and Winston, Inc., 1969, p. 181 ff.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right.

OPERATING INSTRUCTIONS

1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]

2. Key [RUN] [CR/LF]

3. INSTRUCTION — NO. OF PAIRS

4. Key NO. OF PAIRS [CR/LF]

5. INSTRUCTION — INPUT PAIRS OF DATA

> The pairs (X_i, Y_i) are inputed 1/line as follows:
>
> : X_1, Y_1
> : X_2, Y_2
> ⋮
> : X_N, Y_N
>
> Note: The pairs are separated by a comma.

6. Key X_1 , Y_1 [CR/LF]

   Key X_2 , Y_2 [CR/LF]

   ⋮

   Key X_N , Y_N [CR/LF]

7. Read

EXAMPLE

For the following data, find T.

12	16
11	9
12	15
10	9
9	12
7	9
6	10
4	9
4	3

NO. OF PAIRS

4. Key 9 [CR/LF]

INPUT PAIRS OF DATA

6. Key 1 2 , 1 6 [CR/LF]

   Key 1 1 , 9 [CR/LF]

   ⋮

   Key 4 , 3 [CR/LF]

T = 6.5

END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

MANN-WHITNEY U-TEST

TITLE

PS.01-2200.01A-00FI-15-0 | 6/1/73

NUMBER | DATE

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Performs the Mann-Whitney U test given two samples.

BLOCK	SAVE "NAME"	BYTES REQUIRED
15		1574

PROGRAM DESCRIPTION

Performs the Mann-Whitney U-test given two samples. The size of samples 1 and 2 must be $\leq$ 40.

Ref.: Roscoe, John T., "Fundamental Research Statistics", Holt, Rinehart and Winston, Inc., 1969, p. 175 ff.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS

EXAMPLE

Find u for these 2 samples

Sample 1

4, 4, 1, 3, 2, 5, 5, 8, 9, 9

Sample 2

7, 6, 4, 7, 10, 8, 10, 8, 11, 9

1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]

2. Key [RUN] [CR/LF]

3. INSTRUCTION — ENTER N 1

4. Key SIZE OF SAMPLE 1 [CR/LF] — 4. Key 1 0 [CR/LF]

5. INSTRUCTION — ENTER SAMPLE 1

> Input samples 1 and 2 when requested. The samples are inputed 4 elements/line completing the last input line with zeroes if necessary. For example, the sample (1, 2, 3, 4, 5, 6, 6, 8, 9, 10) would be inputed in 3 steps as follows:
>
> : 1, 2, 3, 4
> : 5, 6, 7, 8
> : 9, 10, 0, 0
>
> Note: The elements of an input line are separated by a comma.

6. Key SAMPLE 1(4 ELEMENTS/LINE) [CR/LF] — 6. Key 4 , 4 , 1 , 3 [CR/LF]
   Key 2 , 5 , 5 , 8 [CR/LF]
   Key 9 , 9 , 0 , 0 [CR/LF]

7. The information for Sample 2 will be entered in the same manner as Sample 1. Therefore go to Step 3 and enter data of Sample 2.

8. Read — U = 21

END PROGRAM

PROBABILITY

BLOCK	PROGRAM TITLE
16	NORMAL FREQUENCY AND DISTRIBUTION FUNCTIONS
17	NEGATIVE BINOMIAL DISTRIBUTION
18	BINOMIAL DISTRIBUTION
19	POISSON DISTRIBUTION
20	F-VALUE
21	T-VALUE
22	RANDOM NORMAL DEVIATES

WANG 2200 SERIES PROGRAM

NORMAL FREQUENCY AND DISTRIBUTION FUNCTIONS
TITLE

PS.01-2200.01A-00FI-16-0 — 6/1/73
NUMBER — **DATE**

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Computes values of the normal frequency and normal distribution functions.

BLOCK	SAVE "NAME"	BYTES REQUIRED
16		607

PROGRAM DESCRIPTION

Computes values of the normal frequency and normal distribution functions. The frequency function is:

$$(1)\quad f(x) = \frac{1}{\sqrt{2\pi}} \left(e^{\frac{-X^2}{2}} \right) \quad 0 \leq X \leq \infty$$

The distribution function is:

$$(2)\quad Q(X) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{X} e^{\frac{-X^2}{2}} \, dX$$

Equations (1), (2) are for standardized variables. We say, Y is normal (M, σ), if $X = (Y-M)/\sigma$ has the distribution and frequency functions above (where M = mean, σ = standard deviation). The program has the option to standardize the variable if it is not already standardized.

The distribution function is approximated as follows. Given an $X \geq 0$, define $Y = 1/(1+P*X)$, $P = .33267$ then,

$$Q(X) = 1 - e^{\frac{-X^2}{2}} (A_1 Y + A_2 Y^2 + A_3 Y^3) / \sqrt{2\pi} + E$$

where:

$|E| \leq 10^{-5}$

$A_1 = .4361836$

$A_2 = -.1201676$

$A_3 = .937298$

For $X < 0$, $Q(X) = 1 - Q(-X)$

$f(X) = f(-X)$

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Find F(X), Q(X) for: a standardized variable = 1.5
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	INPUT '0' FOR A STANDARDIZED VARIABLE OR '1' FOR A NON-STANDARDIZED VARIABLE
4. Key 0 [CR/LF] or Key 1 [CR/LF]	4. Key 0 [CR/LF]

If you have a standardized variable go to Step 7. Otherwise, go to Step 5.

5. INSTRUCTION	INPUT 'MEAN, STANDARD DEVIATION'
6. Key MEAN , STD. DEV. [CR/LF]	
7. INSTRUCTION	INPUT 'X' (or '99999' TO END PROGRAM)
8. Key X [CR/LF]	8. Key 1 . 5 [CR/LF]
9. Read:	F(X) = .1295175943551 Q(X) = .933198107297
10. INSTRUCTION	INPUT 'X"
11. Go to Step 8.	

This page intentionally left blank

WANG 2200 SERIES PROGRAM

NEGATIVE BINOMIAL DISTRIBUTION
TITLE

PS. 01-2200. 01A-00FI-17-0 6/1/73
NUMBER **DATE**

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Computes values of the Negative Binomial Distribution.

BLOCK	SAVE "NAME"	BYTES REQUIRED
17		639

PROGRAM DESCRIPTION

The negative binomial distribution given by:

$$P(K,R,P) = \frac{(R+K-1)!}{K!\ (R-1)!}\ P^R Q^K$$

is a discrete distribution used in solving waiting time problems. It calculates the probability that the Rth success will occur at a given trial number R + K, in a succession of N Bernoulli trials. This program is restricted to R a positive integer.

The program computes P(K, R, P) and keeps a running sum of the probabilities calculated.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS

EXAMPLE

Find P(K, R, P) for:

K	R	P
1	2	.5
3	4	.5

and the sum of probabilities.

1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]

2. Key [RUN] [CR/LF]

3. INSTRUCTION — INPUT 'K, R, P' (OR '0, 0, -1) TO PRINT THE SUM OF THE PROBABILITIES CALCULATED THUS FAR, OR '0, 0, 0' TO END PROGRAM)

4. Key K , R , P [CR/LF] — 4. Key 1 , 2 , . 5 [CR/LF]

5. Read: — P(K, R, P) = .2499999999999

6. INSTRUCTION — INPUT 'K, R, P'

7. Go to Step 4. — Key 3 , 4 , . 5 [CR/LF]

P(K, R,) = .15625

INPUT 'K, R, P'

Key 0 , 0 , - 1 [CR/LF]

SUM OF PROBABILITIES = .4062499999999

INPUT 'K, R, P'

Key 0 , 0 , 0 [CR/LF]

END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

BINOMIAL DISTRIBUTION

TITLE

PS. 01-2200. 01A-00FI-18-0 | 6/1/73

NUMBER | DATE

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

The program computes values of the Binomial Distribution.

BLOCK	SAVE "NAME"	BYTES REQUIRED
18		631

PROGRAM DESCRIPTION

The binomial distribution given by:

$$P(K,N,P) = \frac{N!}{K!\,(N-K)!} P^K Q^{N-K}$$

is a discrete distribution giving the probability of obtaining exactly K successes in N Bernoulli trials.

The program computes P(K, N, P) and keeps a running sum of the probabilities calculated.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Find P(K, N, P) for

K	N	P
1	5	.5
2	5	.5

and the sum of probabilities.

1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]
2. Key [RUN] [CR/LF]
3. INSTRUCTION — INPUT 'K, N, P' (OR '0, 0, -1' TO PRINT THE SUM OF PROBABILITIES CALCULATED THUS FAR, OR '0, 0, 0' TO END PROGRAM)
4. Key K , N , P [CR/LF] — 4. Key 1 , 5 , . 5 [CR/LF]
5. Read: — P(K, N, P) = .15625
6. INSTRUCTION — INPUT 'K, N, P'
7. Go to Step 4. — Key 2 , 5 , . 5 [CR/LF]

P(K, N, P) = .3124999999998

INPUT 'K, N, P'

Key 0 , 0 , - 1 [CR/LF]

SUM OF PROBABILITIES = .4687499999998

INPUT 'K, N, P'

Key 0 , 0 , 0 [CR/LF]

END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

POISSON DISTRIBUTION

TITLE

PS.01-2200.01A-00FI-19-0 — 6/1/73

NUMBER — DATE

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Computes values of the Poisson Distribution

BLOCK	SAVE "NAME"	BYTES REQUIRED
19		481

PROGRAM DESCRIPTION

The Poisson distribution given by:

$$P(K,\lambda) = \frac{e^{-\lambda}\lambda^{K}}{K!}$$

is a discrete distribution concerned with the occurrence of relatively rare events. K is the frequency, $P(K,\lambda)$ is the probability associated with that frequency, and λ is the expected frequency.

The program computes $P(K,\lambda)$ and keeps a running total of the probabilities calculated.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Find P(K,λ) for K = 9, λ = 10 K = 7, λ = 10 and the sum of probabilities
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	INPUT 'K, LAMBDA (OR '-1, -1' TO PRINT THE SUM OF THE PROBABILITIES CALCULATED THUS FAR, or '0,0' TO END PROGRAM).
4. Key K , LAMBDA [CR/LF]	4. Key 9 , 1 0 [CR/LF]
5. Read:	P(K, LAMBDA) = .125110035723
6. INSTRUCTION	INPUT 'K, LAMBDA'
7. Go to Step 4.	Key 7 , 1 0 [CR/LF]
	P(K, LAMBDA) = 9.00792257E-02
	INPUT 'K, LAMBDA'
	Key - 1 , - 1 [CR/LF]
	SUM OF PROBABILITIES = .2151892614230
	INPUT 'K, LAMBDA'
	Key 0 , 0 [CR/LF]
	END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

F-VALUE

TITLE

PS. 01-2200. 01A-00FI-20-0 — NUMBER

6/1/73 — DATE

2200A-01, 2215, 2216/2217 — EQUIPMENT

PROGRAM ABSTRACT

Computes values of the probability of the F-ratio.

BLOCK	SAVE "NAME"	BYTES REQUIRED
20		725

PROGRAM DESCRIPTION

Computes the probability of an F-ratio with N degrees of freedom in the numerator and D degrees of freedom in the denominator.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Find the value of the F-ratio of 28.7 with 1 degree of freedom in the numerator and 8 degrees of freedom in denominator.
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	F-VALUE? (TO END PROGRAM INPUT 99999)
4. Key F-VALUE [CR/LF]	4. Key 2 8 . 7 [CR/LF]
5. INSTRUCTION	DEG. FREEDOM IN NUMERATOR?
6. Key DEG. FREEDOM IN NUMERATOR [CR/LF]	6. Key 1 [CR/LF]
7. INSTRUCTION	DEG. FREEDOM IN DENOMINATOR?
8. Key DEG. FREEDOM IN DENOMINATOR [CR/LF]	8. Key 8 [CR/LF]
9. Read	PROBABILITY OF F= 9.83000000E-04
10. INSTRUCTION	F-VALUE?
11. Go to Step 4.	

This page intentionally left blank

WANG 2200 SERIES PROGRAM

T-VALUE

TITLE

PS.01-2200.01A-00FI-21-0 — 6/1/73

NUMBER — DATE

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Computes the probability of a T-value.

BLOCK	SAVE "NAME"	BYTES REQUIRED
21		677

PROGRAM DESCRIPTION

Computes the probability of a T-value for a two-tailed test with N degrees of freedom.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Find P(2.2) for 4 deg. of freedom and P(.7) for 3 deg. of freedom.
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	T-VALUE? (TO END PROGRAM INPUT 99999)
4. Key T-VALUE [CR/LF]	4. Key 2 . 2 [CR/LF]
5. INSTRUCTION	DEG. FREEDOM?
6. Key DEG. OF FREEDOM [CR/LF]	6. Key 4 [CR/LF]
7. Read:	PROBABILITY OF T = 9.22090000E-02
8. INSTRUCTION	T-VALUE?
9. Go to Step 4.	Key . 7 [CR/LF]
	DEG. FREEDOM?
	Key 3 [CR/LF]
	PROBABILITY OF T = .536536
	T-VALUE?
	Key 9 9 9 9 9 [CR/LF]
	END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

RANDOM NORMAL DEVIATES
TITLE

PS.01-2200.01A-00FI-22-0 — 6/1/73
NUMBER — **DATE**

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Generates random normal deviates.

BLOCK	SAVE "NAME"	BYTES REQUIRED
22		335

PROGRAM DESCRIPTION

Generates random normal deviates with a mean of zero and a variance of one.

Ref.: "Handbook of Mathematical Functions", National Bureau of Standards Applied Mathematics Series .55, 1968, p. 953.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Find 20 Random Normal Deviates?
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	NO. OF RANDOM NORMAL DEVIATES
4. Key No. of Random Normal Deviates [CR/LF]	4. Key 2 0 [CR/LF]
5. Read	

```
NO.  OF RANDOM NORMAL DEVIATES
-1.383557232697  1.022692621501  .1215135834351 -1.364422270283
-.8948073958194  .3948850845874  .6570253793798 -.5282952951161
-1.255201373407 -.9817867253492 -1.962471742495 -1.791781668457
 1.375546518128  .3341626351156 -.7562615685378  .7685680757243
 1.128744313775 -1.01863679351  -1.177084245438  .2473385189663
```

This page intentionally left blank

MISCELLANEOUS STATISTICS

BLOCK	PROGRAM TITLE
23	MEAN, VARIANCE, STANDARD DEVIATION I
24	MEAN, VARIANCE, STANDARD DEVIATION II
25	GEOMETRIC MEAN AND STANDARD DEVIATION
26	CROSS-COVARIANCE OF TIME SERIES
27	AUTO-COVARIANCE OF TIME SERIES
28	SYSTEM RELIABILITY
29	ERROR FUNCTION

This page intentionally left blank

WANG 2200 SERIES PROGRAM

MEAN, VARIANCE, STANDARD DEVIATION I
TITLE

PS. 01-2200. 01A-00FI-23-0 — 6/1/73
NUMBER — **DATE**

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Computes the mean, variance and standard deviation for ungrouped data.

BLOCK	SAVE "NAME"	BYTES REQUIRED
23		532

PROGRAM DESCRIPTION

Computes the mean, variance, and standard deviation for ungrouped data.

For a population:

$$\text{mean} = (\Sigma X_i)/N$$

$$\text{variance} = \left(\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{N}\right) /N$$

$$\text{st. dev.} = \sqrt{\text{variance}}$$

where: N = no. of observations
$X_1, X_2, \ldots, X_n$ = observed values

For a sample: the divisor in the variance formula is N - 1 rather than N.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Find the mean, variance and standard deviation of the following population. Observed Values 2, 3, 4, 5, 6
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	INPUT 0 FOR A POPULATION, 1 FOR A SAMPLE
4. Key 0 [CR/LF] or Key 1 [CR/LF]	4. Key 0 [CR/LF]
5. INSTRUCTION	NO. OF OBSERVATIONS
6. Key NO. OF OBSERVATIONS [CR/LF]	6. Key 5 [CR/LF]
7. INSTRUCTION	INPUT OBSERVATIONS 4/LINE

> The observed values are inputed 4/line. If necessary, complete the last input line with zeroes. Separate each element of an input line with a comma.

8. Key OBSERVED VALUES (4/LINE) [CR/LF]	8. Key 2 , 3 , 4 , 5 [CR/LF] Key 6 , 0 , 0 , 0 [CR/LF]
9. Read	MEAN = 4 VARIANCE = 2 ST. DEV. = 1.4142135624 END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

MEAN, VARIANCE, STANDARD DEVIATION II

TITLE

PS. 01-2200. 01A-00FI-24-0   6/1/73

NUMBER   **DATE**

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Computes the mean, variance, and standard deviation for grouped data.

BLOCK	SAVE "NAME"	BYTES REQUIRED
24		481

PROGRAM DESCRIPTION

Computes the mean, variance, and standard deviation for grouped data.

For a population:

$$\text{mean} = \left(\sum_{i=1}^{M} X_i \; f_i \right) / N$$

$$\text{variance} = \left(\sum_{i=1}^{M} X_i^2 f_i - \left(\sum_{i=1}^{M} X_i f_i \right)^2 / N \right) / N$$

$$\text{st. dev.} = \sqrt{\text{variance}}$$

where: X_i = ith observed value

f_i = number of times X_i occurred.

$$N = \sum_{i=1}^{M} f_i$$

M = number of observed values.

For a sample, the divisor in the variance formula is N - 1 rather than N.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Find mean, variance, and standard deviation for the following data taken from a population.

X	freq
61	5
64	18
67	42
70	27
73	8

1. Key [RESET] [CLEAR] [CR/LF]
   [LOAD] [CR/LF]

2. Key [RUN] [CR/LF]

Operating Instructions	Example
3. INSTRUCTION	INPUT 0 FOR A POPULATION, 1 FOR A SAMPLE
4. Key 0 [CR/LF] or Key 1 [CR/LF]	4. Key 0 [CR/LF]
5. INSTRUCTION	NO. OF OBSERVATIONS
6. Key NO. OF OBSERVATIONS [CR/LF]	6. Key 5 [CR/LF]
7. INSTRUCTION	INPUT XI, FI (1 = 1, 2, . . .M)

> The observed value and its frequency is a data pair. Each data pair is an input line, where the two elements of the pair are separated by a comma.

Operating Instructions	Example
8. Key X_1 , F_1 [CR/LF]	8. Key 6 1 , 5 [CR/LF]
Key X_2 , F_2 [CR/LF]	Key 6 4 , 1 8 [CR/LF]
⋮	⋮
Key X_M , F_M [CR/LF]	Key 7 3 , 8 [CR/LF]

OPERATING INSTRUCTIONS (Cont)

9. Read

MEAN = 67.45

VARIANCE = 8.5275

ST. DEV. = 2.9201883501

END PROGRAM

WANG 2200 SERIES PROGRAM

GEOMETRIC MEAN AND STANDARD DEVIATION
TITLE

PS. 01-2200. 01A-00FI-25-0 — 6/1/73
NUMBER — DATE

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Computes the geometric mean and geometric standard deviation for a geometrically normal set of data.

BLOCK	SAVE "NAME"	BYTES REQUIRED
25		368

PROGRAM DESCRIPTION

Computes the geometric mean and geometric standard deviation for a geometrically normal set of data.

$$\text{Geometric Mean} = (A_1 \cdot A_2 \cdot A_3 \ldots A_N)^{1/N}$$

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS

1. Key [RESET] [CLEAR] [CR/LF]
   [LOAD] [CR/LF]
2. Key [RUN] [CR/LF]
3. INSTRUCTION
4. Key NO. OF DATA ELEMENTS [CR/LF]
5. INSTRUCTION
6. Key A_1 [CR/LF]

   Key A_2 [CR/LF]

   .
   .
   .

   Key A_N [CR/LF]
7. Read

EXAMPLE

Find the geometric mean and the geometric standard deviation for the following data:

10, 52, 63, 42, 12, 25, 95, 46, 48, 10

NO. OF DATA ELEMENTS

4. Key 1 0 [CR/LF]

DATA ELEMENTS 1/LINE

6. Key 1 0 [CR/LF]

   Key 5 2 [CR/LF]

   .
   .
   .

   Key 1 0 [CR/LF]

GEOMETRIC MEAN IS: 31.17049587113

GEOMETRIC STANDARD DEVIATION IS:
2.258031500973

END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

CROSS-COVARIANCE OF TIME SERIES

TITLE

PS. 01-2200. 01A-00FI-26-0 6/1/73

NUMBER **DATE**

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Finds the cross-covariances of series A with series B (which leads and lags A).

BLOCK	SAVE "NAME"	BYTES REQUIRED
26		1793

PROGRAM DESCRIPTION

Finds the cross-covariance of a series A with series B (which leads and lags A). The lag covariance and the lead covariance are calculated for lags and leads of 0, 1, 2, ..., L-1 where L $<$ N and N = number of elements in series A and B.

($N \leq 70$)

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS

EXAMPLE

Find the cross-covariance of series A with series B (L = 5).

Series A

1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Series B

3, 6, 11, 18, 27, 38, 51, 66, 83, 102

1. Key [RESET] [CLEAR] [CR/LF]
   [LOAD] [CR/LF]
2. Key [RUN] [CR/LF]
3. INSTRUCTION — INPUT N, L
4. Key N , L [CR/LF] — 4. Key 1 0 , 5 [CR/LF]
5. INSTRUCTION — INPUT SERIES A AND B, 2 ELEMENTS/ LINE i.e. A1, B1, CARRIAGE RETURN, A2, B2, CARRIAGE RETURN, . . .)
6. Key A_1 , B_1 [CR/LF] — 6. Key 1 , 3 [CR/LF]
   Key A_2 , B_2 [CR/LF] — Key 2 , 6 [CR/LF]
   .
   .
   .
   Key A_N , B_N [CR/LF] — Key 1 0 , 1 0 2 [CR/LF]
7. Read

LAG/LEAD	LAG COVARIANCE	LEAD COVARIANCE
0	90.75	90.75
1	77.91666666667	63.25
2	59.25	34.25
3	34.25	4.25
4	2.41666666667	-26.25

This page intentionally left blank

WANG 2200 SERIES PROGRAM

AUTO COVARIANCE OF A TIME SERIES
TITLE

PS. 01-2200. 01A-00FI-27-0 — 6/1/73
NUMBER — **DATE**

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Finds the auto-covariance of a time series.

BLOCK	SAVE "NAME"	BYTES REQUIRED
27		1345

PROGRAM DESCRIPTION

Finds the autocovariances of a time series for lags of 0 to L where $L < N$ and N = number of elements in the series. ($N \leq 96$)

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	For the time series 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 13, 14, 15, 16 find autocovariances for 7 lags
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	INPUT N, L
4. Key N , L [CR/LF]	4. Key 1 6 , 7 [CR/LF]
5. INSTRUCTION	INPUT SERIES, 4 ELEMENTS/LINE. IF NECESSARY FILL LAST INPUT LINE WITH ZEROES.

The series $A_1, A_2, \ldots, A_N$ is inputed 4 elements/line. Complete the last line with zeroes if necessary. For example, 1, 2, 3, 4, 5, 6 is inputed as follows:

1, 2, 3, 4, [CR/LF]

5, 6, 0, 0, [CR/LF]

6. Key A_1 , A_2 , A_3 , A_4 [CR/LF] Continue until all elements have been entered.	6. Key 1 , 2 , 3 , 4 [CR/LF] Key 5 , 6 , 7 , 8 [CR/LF] Key 9, ,, 1, 0, ,, 1, 1, ,, 1, 2, [CR/LF] Key 1 3 , 1 4 , 1 5 , 1 6 [CR/LF]

7. Read:

LAGS	AUTOCOVARIANCE
0	21.25
1	18.41666666667
2	15.25
3	11.75
4	7.916666666667
5	3.75
6	-.75

WANG 2200 SERIES PROGRAM

SYSTEM RELIABILITY

TITLE

PS. 01-2200. 01A-00FI-28-0 — 6/1/73

NUMBER — DATE

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Calculates the system reliability when chance failure is present along with wearout.

BLOCK	SAVE "NAME"	BYTES REQUIRED
28		327

PROGRAM DESCRIPTION

Calculates the system reliability when chance failure is present along with wearout.

$$R = e^X, \quad X = \sum_{i=1}^{N} \left(L_i + \frac{1}{M_i}\right)t$$

where:

R = system reliability
M_i = mean wearout time of ith component (hrs.)
L_i = chance failure rate of ith component
t = operating time (hrs.)

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE

EXAMPLE

Component	Mean Wearout	Chance Failure
1	6000	.0001
2	6500	.00015
3	7000	.0002

Operating Time = 1000

Find value of system reliability

1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]
2. Key [RUN] [CR/LF]
3. INSTRUCTIONS — NO. OF COMPONENTS, OPERATING TIME
4. Key NO. OF COMPONENTS , OPERATING TIME [CR/LF] — 4. Key 3 , 1 0 0 0 [CR/LF]
5. INSTRUCTION — MEAN WEAROUT TIME, CHANCE FAILURE RATE FOR COMPONENT 1
6. Key MEAN WEAROUT TIME , CHANCE FAILURE, [CR/LF] — 6. Key 6 0 0 0 , . 0 0 0 1 [CR/LF]

> The program will loop to Step 5 until the mean wearout time and chance failure rate for each component has been inputed. After all components have been entered go to Step 7.

7. Read: — SYSTEM RELIABILITY = .4011700152417

END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

ERROR FUNCTION

TITLE

PS.01-2200.01A-00FI-29-0 — 6/1/73

NUMBER — **DATE**

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Computes values of the error function.

BLOCK	SAVE "NAME"	BYTES REQUIRED
29		1034

PROGRAM DESCRIPTION

Computes the definite integral of the function

$$E(X) = \frac{2}{\sqrt{\pi}} e^{-X^2}$$

between the limits of 0 and X, using the trapezoidal rule with Romberg's extrapolation. The integral is calculated to 4 significant digits.

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Find the value of the error function at 3 and 5.
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	TO END PROGRAM INPUT 0. INPUT 'INTEGRATION LIMIT X'
4. Key X [CR/LF]	4. Key 3 [CR/LF]
5. Read	INTEGRAL = .9999779835828
6. INSTRUCTION	INPUT 'INTEGRATION LIMIT X'
	Key 5 [CR/LF]
	INTEGRAL = .9999989816139
	INPUT 'INTEGRATION LIMIT X'
	Key 0 [CR/LF]
	END PROGRAM

This page intentionally left blank

ENGINEERING

BLOCK	PROGRAM TITLE
30	TALBOT'S FORMULA
31	MANNING'S FORMULA
32	HEADLOSS IN A PIPE
33	BERNOULLI'S EQUATION
34	WARPING STRESS DUE TO TEMPERATURE DIFFERENTIAL
35	PRESSURE DUE TO SURFACE LOADS, PRINT LOADS, FINITE OR INFINITE LINE LOADS
36	BEAM
37	OIL WELL DEPLETION
38	NETWORK IMPEDANCE - FINDING A SERIES OR PARALLEL CIRCUIT
39	CHARACTERISTIC GENERATOR RESISTANCE AND SOURCE emf VOLTAGE
40	"ERLANG B" EQUATION

This page intentionally left blank

WANG 2200 SERIES PROGRAM

TALBOT'S FORMULA
TITLE

PE. 11-2200. 01A-00FI-1-0 — 6/1/73
NUMBER — **DATE**

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Estimates the area of waterway opening required for culverts.

BLOCK	SAVE "NAME"	BYTES REQUIRED
30		217

PROGRAM DESCRIPTION

Talbot's formula is one of the best known empirical formulas for estimating the area of waterway opening required for culverts.

$$a = CA^{3/4}$$

where:

a = Required Waterway Opening

A = Drainage Area (Acres)

C = Runoff Coefficient

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	A = 2.1 acres C = .5
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	DRAINAGE AREA?
4. Key Area (In Acres) [CR/LF]	4. Key 2 . 1 [CR/LF]
5. INSTRUCTION	RUNOFF COEFF.?
6. Key Runoff Coeff. [CR/LF]	6. Key . 5 [CR/LF]
7. Read	REQUIRED WATERWAY OPENING = .8722369398
8. INSTRUCTION	MORE INPUT? (1 = YES, 0 = NO)
9. Key 0 [CR/LF] or Key 1 [CR/LF]	9. Key 0 [CR/LF]

If you have more input, go to Step 3. Otherwise, go to Step 10.

10.	END PROGRAM

This page intentionally left blank

WANG
2200
SERIES
PROGRAM

MANNING'S FORMULA

TITLE

PE. 11-2200. 01A-00FI-2-0	6/1/73
NUMBER	**DATE**

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Computes the discharge quantity for open channel flow.

BLOCK	SAVE "NAME"	BYTES REQUIRED
31		411

PROGRAM DESCRIPTION

This program combines Manning's formula for velocity of water flow with the general flow formula to determine the discharge quantity for open-channel flow.

$$Q = \frac{1.486}{n} AR^{2/3}S^{1/2}$$

where:

Q = Discharge (ft^3/sec)

A = Area of flow cross section (ft^2)

n = Manning's roughness coefficient

R = Hydraulic radius (ft)

S = Slope of channel (ft/ft)

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	$A = 20\ ft^2$ S = .003 n = .03 R = 2.5 ft.
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	AREA OF FLOW CROSS SECTION (SQ. FT.)?
4. Key A [CR/LF]	4. Key 2 0 [CR/LF]
5. INSTRUCTION	MANNING'S ROUGHNESS COEFF.?
6. Key n [CR/LF]	6. Key . 0 3 [CR/LF]
7. INSTRUCTION	HYDRAULIC RADIUS (FT.)?
8. Key R [CR/LF]	8. Key 2 . 5 [CR/LF]
9. INSTRUCTION	SLOPE OF CHANNEL (FT/FT)?
10. Key S [CR/LF]	10. Key . 0 0 3 [CR/LF]
11. Read	DISCHARGE = 99.94970504597 CU. FT.?SEC.
12. INSTRUCTION	MORE INPUT? (1 = YES, 0 = NO)
13. Key 0 [CR/LF] or Key 1 [CR/LF]	13. Key 0 [CR/LF]

If you have more input, go to Step 3. Otherwise, go to Step 14.

14.	END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

HEADLOSS IN A PIPE
TITLE

PE. 11-2200. 01A-00FI-3-0 — NUMBER
6/1/73 — DATE

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Computes the headloss between two reservoires on different levels.

BLOCK	SAVE "NAME"	BYTES REQUIRED
32		337

PROGRAM DESCRIPTION

This program calculates the head loss between two reservoires on different levels. Friction factor, pipe O. D. and length of the line are related to the head loss which is calculated in the following formula:

$$H = \left[f \frac{L}{D} + 1.5 \right] \frac{V^2}{2a}$$

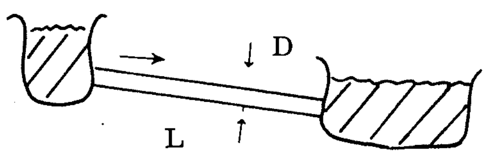
$$H = \left[f \frac{L}{D} + 1.5 \right] \left[\frac{(16/(\pi \cdot D^2))^2}{64.4} \right]$$

where: H = Head loss in ft.

L = Length in ft.

D = O-Diameter of pipe in ft.

f = Friction Factor



NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	L = 150' f = .013 D = .667'
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	LENGTH (FT)?
4. Key L [CR/LF]	4. Key 1 5 0 [CR/LF]
5. INSTRUCTION	0-DIAMETER OF PIPE (FT.)?
6. Key D [CR/LF]	6. Key . 6 6 7 [CR/LF]
7. INSTRUCTION	FRICTION FACTOR
8. Key f [CR/LF]	8. Key . 0 1 3 [CR/LF]
9. Read	HEADLOSS = 9.01622697414
10. INSTRUCTION	MORE INPUT? (1=YES, 0=NO)
11. Key 0 [CR/LF] or Key 1 [CR/LF]	11. Key 0 [CR/LF]

If you have more input, go to Step 3. Otherwise go to Step 12.

12.	END PROGRAM

This page intentionally left blank

WANG 2200 SERIES PROGRAM

BERNOULLI'S EQUATION

TITLE

PE. 11-2200. 01A-00FI-4-0 — 6/1/73

NUMBER — **DATE**

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Computes the headwater depth of culverts flowing full.

BLOCK	SAVE "NAME"	BYTES REQUIRED
33		424

PROGRAM DESCRIPTION

This program uses Bernoulli's equation to compute the headwater depth of Culverts flowing full.

$$H = (1 + K_e + \frac{2\ 9n^2 L)}{R^{4/3}} \quad \frac{V^2}{2g}$$

where:

H = DIFFERENCE IN ELEVATION BETWEEN HEADWATER ELEVATION AND ELEVATION OF TAILWATER SURFACE, OR DIFFERENCE BETWEEN HEADWATER ELEVATION AND CROWN AT OUTLET WHEN CULVERT IS FLOWING FULL WITHOUT TAILWATER BEING ABOVE CROWN (FT)

$V^2/2g$ = Velocity Head (ft)

Ke = Coefficient of Entrance Loss.

n = Manning's Roughness Coefficient

L = Length of Culvert (ft)

R = Hydraulic Radius (ft)

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	R = 2.5 ft. L = 70 ft. n = .015 K_e = .2 $V^2/2g$ = .8 ft.
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	VELOCITY HEAD (FT.)?
4. Key $V^2/2g$ [CR/LF]	4. Key . 8 [CR/LF]
5. INSTRUCTION	COEFF. OF ENTRANCE LOSS?
6. Key K_e [CR/LF]	6. Key . 2 [CR/LF]
7. INSTRUCTION	MANNING'S ROUGHNESS COEFF.?
8. Key n [CR/LF]	8. Key . 0 1 5 [CR/LF]
9. INSTRUCTION	LENGTH OF CULVERT (FT.)?
10. Key L [CR/LF]	10. Key 7 0 [CR/LF]
11. INSTRUCTION	HYDRAULIC RADIUS (FT.)?
12. Key R [CR/LF]	12. Key 2 . 5 [CR/LF]
13. Read	HEADWATER DEPTH (FT.) = 1.0676916087
14. INSTRUCTION	MORE INPUT? (1 = YES, 0 = NO)
15. Key 0 [CR/LF] or Key 1 [CR/LF]	15. Key 0 [CR/LF]

If you have more input, go to Step 3. Otherwise, go to Step 16.

16. END PROGRAM

WANG 2200 SERIES PROGRAM

WARPING STRESS DUE TO A TEMPERATURE DIFFERENTIAL
TITLE

PE. 11-2200. 01A-00F I-5-0 — 6/1/73
NUMBER — **DATE**

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Computes the warping stress in two directions which exist in the center of a slab of concrete pavement.

BLOCK	SAVE "NAME"	BYTES REQUIRED
34		470

PROGRAM DESCRIPTION

This program computes the warping stress in two directions which exist in the center of a slab of concrete pavement.

$$S_t = \frac{E_c et}{2} \left(\frac{C_1 + \mu C_2}{1 - \mu^2} \right)$$

where:

S_t = warping stress (psi)

E_c = modulus of elasticity of concrete (psi)

t = temperature differential

C_1 = coefficient of slab length in desired direction

C_2 = coefficient of slab length normal to C_1

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	C_2 = -1.265 C_1 = 1.265 E_c = 5,000,000 psi t = 20
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	MODULUS OF ELASTICITY OF CONCRETE (PSI)?
4. Key E_c [CR/LF]	4. Key 5 0 0 0 0 0 0 [CR/LF]
5. INSTRUCTION	TEMPERATURE DIFFERENTIAL?
6. Key t [CR/LF]	6. Key 2 0 [CR/LF]
7. INSTRUCTION	COEFF. OF SLAB LENGTH IN DESIRED DIRECTION?
8. Key C_1 [CR/LF]	8. Key 1 . 2 6 5 [CR/LF]
9. INSTRUCTION	COEFF. OF SLAB LENGTH NORMAL TO C1?
10. Key C_2 [CR/LF]	10. Key - 1 . 2 6 5 [CR/LF]
11. Read	WARPING STRESS = 275
12. INSTRUCTION	MORE INPUT? (1 = YES, 0 = NO)
13. Key 0 [CR/LF] or Key 1 [CR/LF]	13. Key 0 [CR/LF]

If you have more input, go to Step 3. Otherwise, go to Step 14.

14. END PROGRAM

WANG 2200 SERIES PROGRAM

PRESSURE DUE TO SURFACE LOADS - POINT LOAD, FINITE & INFINITE LINE LOADS
TITLE

PE. 11-2200. 01A-00FI-6-0 — **NUMBER**

6/1/73 — **DATE**

2200A-01, 2215, 2216/2217 — **EQUIPMENT**

PROGRAM ABSTRACT

This program computes horizontal unit pressure due to a point load, or lateral pressure due to a line load either finite or infinite.

BLOCK	SAVE "NAME"	BYTES REQUIRED
35		475

PROGRAM DESCRIPTION

CASE 1 This program computes horizontal unit pressure due to a point load, such as a truck wheel, at any point on the wall of a backfill surface.

$$h_c = P \frac{X^2 Z}{R^5}$$

where:

$$R = \sqrt{X^2 + Y^2 + Z^2}$$

h_c = Horizontal unit pressure (psf)

P = Applied point load (lbs)

X = Horizontal distance from load to wall (ft)

Y = Lateral distance from load to point on wall (ft)

Z = Vertical distance from load to point on wall (ft)

CASE 2 This program computes lateral pressure due to a line load or a narrow strip load of finite length at any depth opposite one end of a parallel strip load on the backfill.

$$h_s = P_s \frac{X^2 Z}{R_1^4} \left[\frac{R_1^2 Y_1}{3 (R_1^2 + Y_1^2)^{3/2}} + \frac{2Y_1}{3(R_1^2 + Y_1^2)^{1/2}} \right]$$

where:

$$R_1 = \sqrt{X^2 + Z^2}$$

h_s = Unit lateral pressure (psf)

P_s = Load per unit length of strip (lbs/ft)

X = Distance back of wall (ft)

Z = Depth of pressure (ft)

Y_1 = Length of strip load (ft)

CASE 3 This program computes the lateral unit pressure due to a line load or narrow strip of infinite length at any depth opposite one end of a parallel strip load on the backfill.

$$h_s = \frac{4}{3} P_s \frac{X^2 Z}{R_1^4}$$

where:

$R_1 = \sqrt{X^2 + Z^2}$

h_s = Unit lateral pressure (psf)

P_s = Load per unit length of strip (lb/ft)

X = Distance back of wall (ft)

Z = Depth of pressure (ft)

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

CASE 1

OPERATING INSTRUCTIONS	EXAMPLE
	X = 10.5 ft. = horizontal distance from load to wall (ft) Y = 11.25 ft. = lateral distance from load to point on wall (ft) Z = 12.0 ft. = vertical distance from load to point on wall (ft) P = 6,000 lbs. = applied point load
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	CASE NO.
4. Key CASE NO. [CR/LF]	4. Key 1 [CR/LF]
5. INSTRUCTION	P, X, Y, Z
6. Key APPLIED POINT LOAD , HORIZONTAL DISTANCE , LATERAL DISTANCE , VERTICAL DISTANCE [CR/LF]	6. Key 6 0 0 0 , 1 0 . 5 , 1 1 . 2 5 , 1 2 [CR/LF]
7. Read:	HC = 2.805001552062
8. INSTRUCTION	ANOTHER CASE (1 = YES, 0 = NO)
9. Key 0 [CR/LF] or Key 1 [CR/LF]	9. Key 0 [CR/LF]

If you have another case go to Step 3. Otherwise, go to Step 10.

10.	END PROGRAM

CASE 2

<u>OPERATING INSTRUCTIONS</u>

<u>EXAMPLE</u>

X = 10.5 ft. Distance Back of Wall (ft).

Z = 12 ft. Depth of pressure (ft)

Y_1 = 11.25 ft. Length of Strip Load (ft)

P_s = 6,000 lb/ft. Load per unit length of strip.

Operating Instructions	Example
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	CASE NO.
4. Key CASE NO. [CR/LF]	4. Key 2, [CR/LF]
5. INSTRUCTION	P, X, Y, Z
6. Key LOAD/UNIT LENGTH OF STRIP , DISTANCE BACK OF WALL , LENGTH OF STRIP LOAD , DEPTH OF PRESSURE [CR/LF]	6. Key 6 0 0 0 , 1 0 . 5 , 1 1 . 2 5 , 1 2 [CR/LF]
7. Read	HS = 62.94973679071
8. INSTRUCTION	ANOTHER CASE (1 = YES, 0 = NO)
9. Key 0 [CR/LF] or Key 1 [CR/LF]	9. Key 0 [CR/LF]

If you have another case, go to Step 3. Otherwise, go to Step 10.

10. END PROGRAM

CASE 3

OPERATING INSTRUCTIONS	EXAMPLE
	X = 10.5 ft. Distance back of wall Z = 12 ft. Depth pressure P_s = 6,000 lb/ft. Load per unit length of strip.
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	CASE NO.
4. Key CASE NO. [CR/LF]	4. Key 3 [CR/LF]
5. INSTRUCTION	P, X, Z
6. Key LOAD PER UNIT LENGTH OF STRIP , DISTANCE BACK OF WALL, , DEPTH PRESSURE, [CR/LF]	6. Key 6 0 0 0 , 1 0 . 5 , 1 2 [CR/LF]
7. Read	HS = 163.729866604
8. INSTRUCTION	ANOTHER CASE (1 = YES, 0 = NO)
9. Key 0 [CR/LF] or Key 1 [CR/LF]	9. Key 0 [CR/LF]

If you have another case, go to Step 3. Otherwise, go to Step 10.

10.	END PROGRAM

WANG 2200 SERIES PROGRAM

BEAM
TITLE

PE. 11-2200. 01A-00FI-7-0 — 6/1/73
NUMBER — **DATE**

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

Program recommends steel beams to use for a number of common applications.

BLOCK	SAVE "NAME"	BYTES REQUIRED
36		2713

PROGRAM DESCRIPTION

This program recommends steel beams to use for a number of common applications.

Input L, B, S, W, P, A when requested.

L =
- 1 for uniformly distributed load
- 2 for single midpoint load
- 3 for uniform load plus single midpoint load
- 4 for two equal symmetric loads

B =
- 1 for beam supported at both ends
- 2 for one end fixed, other end supported
- 3 for beam fixed at both ends
- 4 for one end fixed (cantilever)

S = length of span in feet

W = distributed load in pounds per foot
(set = 0 if not applicable)

P = each concentrated load in pounds
(set = 0 if not applicable)

A = location of load(s) in feet from end
(set = 0 if not applicable)

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. Whenever such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Determine the recommended beam for the following data: L = 1 B = 1 S = 20 ft. W = 50 lbs/ft. P = 0 A = 0
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	L, B, S, W, P, A?
4. Key L , B , S , W , P , A [CR/LF]	Key 1 , 1 , 2 0 , 5 0 , 0 , 0 [CR/LF]
5. Read	RECOMMENDED BEAM IS A 6 JR 4.4
6. INSTRUCTION	MORE INPUT (1 = YES, 0 = NO)
7. Key 0 [CR/LF] or Key 1 [CR/LF]	7. Key 0 [CR/LF]

If you have more input, program goes to Step 3. Otherwise, program ends.

This page intentionally left blank

WANG 2200 SERIES PROGRAM

OIL WELL DEPLETION

TITLE

PE. 04-2200. 01A-00FI-4-0 6/1/73

NUMBER DATE

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Calculates the number of years that an oil well will produce.

BLOCK	SAVE "NAME"	BYTES REQUIRED
37		624

PROGRAM DESCRIPTION

This program calculates the number of years that an oil well will produce given the current production rate, the minimum number of barrels of oil that must be produced to cover expenses and the reserve to be recovered on decline.

$$D = \frac{C}{I \ \mathrm{LOG} \left(\frac{I}{q}\right)}$$

$$Y = \frac{D}{12} \left[\frac{I}{q} - 1\right]$$

where:

C = Reserve to be recovered on decline (barrels)

I = Initial rate (barrels/month)

q = Economic limit rate (barrels/month)

D = Decline rate (months)

Y = Life of decline production of oil well (years)

It also computes the cumulative production for each year plus the unit production for each year

$$CP_n = \mathrm{LOG} \left[\frac{12N}{D} + 1\right] DI$$

$$P_n = CP_n - CP_{n-1}$$

where:

CP_n = cumulative production for nth year

P_n = unit production for nth year

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS

EXAMPLE

Given:

Reserve to be recovered on decline = 50,000 barrels

Initial rate = 1000 barrels/months

Economic Limit Rate = 200 barrels/months

Find the decline rate (months) and the life of decline production of oil well (years)?

1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]
2. Key [RUN] [CR/LF]
3. INSTRUCTION — RESERVE TO BE RECOVERED ON DECLINE (BARRELS)
4. Key RESERVE [CR/LF] — 4. Key 5 0 0 0 0 [CR/LF]
5. INSTRUCTION — INITIAL RATE (BARRELS/MO.)?
6. Key INITIAL RATE [CR/LF] — 6. Key 1 0 0 0 [CR/LF]
7. INSTRUCTION — ECONOMIC LIMIT RATE (BARRELS/MO.)?
8. Key ECONOMIC LIMIT RATE, [CR/LF] — 8. Key 2 0 0 [CR/LF]
9. Read — Y = 10.35558224267

10. Read

CP(1) = 10146.80805834
P(1) = 10146.80805834
CP(2) = 17782.85486478
P(2) = 7636.04680644
CP(3) = 23907.42529636
P(3) = 6124.57043158
CP(4) = 29021.13755731
P(4) = 5113.71226095
CP(5) = 33410.87903326
P(5) = 4389.74147595
CP(6) = 37256.44790239
P(6) = 3845.56886913
CP(7) = 40678.00149686
P(7) = 3421.55359447
CP(8) = 43759.8273348
P(8) = 3081.82583794
CP(9) = 46563.33706577
P(9) = 2803.50973097
CP(10) = 49134.66211213
P(10) = 2571.32504636
CP(11) = 50000
P(11) = 865.33788787

11. INSTRUCTION — MORE INPUT? (1 = YES, 0 = NO)

12. Key 0 or 1 [CR/LF] — 11. Key 0 [CR/LF]

> If you key 1 [CR/LF] , program will go to Step 3. Otherwise program ends.

WANG 2200 SERIES PROGRAM

NETWORK IMPEDANCE - FINDING A SERIES OR PARALLEL CIRCUIT
TITLE

PE.03-2200.01A-00FI-1-0 | 6/1/73
NUMBER | DATE

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

This program is designed to find a series (parallel) circuit that is in parallel (series) by the leaning-ladder method.

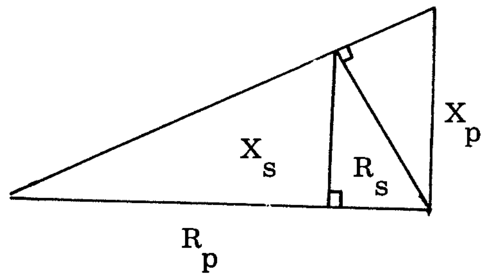
BLOCK	SAVE "NAME"	BYTES REQUIRED
38		393

PROGRAM DESCRIPTION

CASE 1 This program is designed to find a series circuit that is in parallel by the leaning-ladder method

$$R_s = \frac{R_p X_p^2}{(X_p^2 + R_p^2)}$$

$$X_s = \frac{X_p R_p^2}{(X_p^2 + R_p^2)}$$



where:

R_s = Resistance to be in series (ohms)

X_s = Reactance to be in series (ohms)

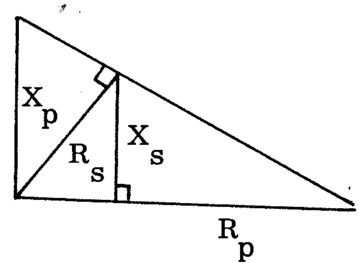
R_p = Resistance in parallel (ohms)

X_1 = Reactance in parallel (ohms)

CASE 2 This program is designed to parallel a circuit that is in series. The method is the leaning ladder method.

$$R_p = R_s + \frac{X_s^2}{R_s}$$

$$X_p = X_s + \frac{R_s^2}{X_s}$$



where:

R_p = Resistance to be paralleled (ohms)

X_1 = reactance to be paralleled (ohms)

R_2 = Resistance in series (ohms)

X_2 = resistance in series (ohms)

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE Resistance = 25 (ohms) Reactance = 50 (ohms) Find RS, XS
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	INPUT CASE NO. (1 OR 2)
Case 1, finds a series circuit Case 2, finds a parallel circuit	
4. Key CASE NO. [CR/LF]	4. Key 1 [CR/LF]
5. INSTRUCTION	RESISTANCE?
6. Key RESISTANCE [CR/LF]	6. Key 2 5 [CR/LF]
7. INSTRUCTION	REACTANCE?
8. Key REACTANCE [CR/LF]	8. Key 5 0 [CR/LF]
If Case no. 1, go to Step 9. If Case no. 2, go to Step 11	
9. Read	RS = 20 RX = 10
10. Go to Step 12	
11. Read	RP = XP =
12. INSTRUCTION	MORE INPUT? (1 = YES, 0 = NO)
13. Key 0 or 1 [CR/LF]	13. Key 0 [CR/LF]

If you keyed 1 [CR/LF], go to Step 3. Otherwise, program ends.

WANG 2200 SERIES PROGRAM

CHARACTERISTIC GENERATOR RESISTANCE AND SOURCE emf VOLTAGE
TITLE

PE. 03-2200. 01A-00FI-2-0
NUMBER

6/1/73
DATE

2200A-01, 2215, 2216/2217
EQUIPMENT

PROGRAM ABSTRACT

This program computes the characteristic generator resistance and the source emf voltage of an efficient rf switched amplifier whose output power swings with mismatch.

BLOCK	SAVE "NAME"	BYTES REQUIRED
39		567

PROGRAM DESCRIPTION

This program computes the characteristic generator resistance and the source emf voltage of an efficient rf switched amplifier whose output power swings with mismatch.

Generator Resistance

$$R_0 = Z_0 \frac{1 - \frac{R_2}{Z_0}\left(\frac{P_{f_{max}}}{P_{f_{min}}}\right)^{1/2}}{\left(\frac{P_{f_{max}}}{P_{f_{min}}}\right)^{1/2} - \frac{R_2}{Z_0}}$$

Source emf Voltage

$$E = \frac{2\,(R_0 + R_2)}{(Z_0 + R_2)} - \sqrt{Z_0\, P_{f_{max}}}$$

where:

R_0 = Characteristic generator resistance (ohms)

Z_0 = Characteristic impedance of transmission line (ohms)

R_2 = Real load resistance (ohms)

$P_{f_{max}}$ = Maximum forward-going power (watts)

$P_{f_{min}}$ = Minimum forward-going power (watts)

E = Source emf voltage (volts)

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Characteristic Impedance of transmission line (ohms) = 50 Real load resistance (ohms) = 16.7 Max. forward-going power (watts) = 100 Min. forward-going power (watts) = 20
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTIONS	CHARA. IMPEDANCE OF TRANSMISSION LINE (OHMS)?
4. Key CHARA. IMPEDANCE [CR/LF]	4. Key 5 0 [CR/LF]
5. INSTRUCTION	REAL LOAD RESISTANCE (OHMS)?
6. Key REAL LOAD RESISTANCE [CR/LF]	6. Key 1 6 . 7 [CR/LF]
7. INSTRUCTION	MAX. FORWARD-GOING POWER (WATTS)?
8. Key MAX. FORWARD-GOING POWER [CR/LF]	8. Key 1 0 0 [CR/LF]
9. INSTRUCTION	MIN. FORWARD-GOING POWER (WATTS)?
10. Key MIN. FORWARD-GOING POWER [CR/LF]	10. Key 2 0 [CR/LF]
11. Read	CHARACTERISTIC GENERATOR RESISTANCE = 6.654685808016 OHMS SOURCE EMF VOLTAGE = 49.51801111596 VOLTS
12. INSTRUCTION	MORE INPUT? (1 = YES, 0 = NO)

13. Key 0 [CR/LF] or Key 1 [CR/LF]	13. Key 0 [CR/LF]

If you have more input, go to Step 3. Otherwise program ends.

WANG 2200 SERIES PROGRAM

"ERLANG B" EQUATION

TITLE

PE. 03-2200. 01A-00FI-3-0 — 6/1/73

NUMBER — **DATE**

2200A-01, 2215, 2216/2217

EQUIPMENT

PROGRAM ABSTRACT

Computes the probability that exactly N equipments will be busy simultaneously when offered to Erlang's (Grade of Service).

BLOCK	SAVE "NAME"	BYTES REQUIRED
40		264

PROGRAM DESCRIPTION

In the administration of a telephone or telex exchange, it is common to estimate the load upon groups of equipments by reading Erlang meters associated with each grouping of equipments.

The purpose of such activities is to determine the grade of service given the number of equipments and the traffic offered. The "Erlang B" equation that is calculated is:

$$P = \frac{T^N}{e^T} N!$$

where:

T = Traffic offered in Erlangs

N = Number of equipments

P = Probability that exactly N equipments will be busy simultaneously when offered to Erlangs (Grade of Service)

NOTE

Many operating instructions are presented via the CRT (display) or one of the output devices. When such instructions occur the word INSTRUCTION will appear on the left hand side of the operating instructions and what is displayed or typed will appear on the right hand side.

OPERATING INSTRUCTIONS	EXAMPLE
	Traffic = 17.075 Erlangs # of equipment = 24.
1. Key [RESET] [CLEAR] [CR/LF] [LOAD] [CR/LF]	
2. Key [RUN] [CR/LF]	
3. INSTRUCTION	TRAFFIC IN ERLANGS
4. Key TRAFFIC [CR/LF]	4. Key 1 7 . 0 7 5 [CR.LF]
5. INSTRUCTION	NO. OF EQUIPMENTS
6. Key No. of Equipments [CR/LF]	6. Key 2 4 [CR/LF]
7. Read:	P = 2.33546384E-02
8. INSTRUCTION	MORE INPUT (1 = YES, 0 = NO)
9. Key 0 [CR/LF] or Key 1 [CR/LF]	9. Key 0 [CR/LF]

If you have more input, go to Step 3. Otherwise program ends.

Jack Jarvis & Company, Inc.
707 S. W. Washington Street
Portland, Oregon 97205
Telephone: (503) 224-7838

WANG LABORATORIES (CANADA) LTD.
180 Duncan Mill Road
Don Mills, Ontario M3B 1Z6
TELEPHONE (416) 449-7890
TELEX 06-21-7549

WANG EUROPE, S.A.
Buurtweg 13
9412 Ottergem
Belgium
TELEPHONE: 053/74514
TELEX: 26077

WANG ELECTRONICS LTD.
40-44 High Street
Northwood, Middlesex, England
TELEPHONE Northwood 27677

WANG FRANCE SARL
47, Rue de la Chapelle
Paris 18, France
TELEPHONE 203.27.94 or 203.25.94

WANG LABORATORIES GMBH
Moselstrasse No. 4
6000 Frankfurt am Main
West Germany
TELEPHONE (611) 23-00-40

WANG SKANDINAVISKA AB
Fredsgaten 17
S-172-23
Sundbyberg 1, Sweden
TELEPHONE 08-98-12-45

WANG NEDERLAND B.V.
Damstraat 2
Utrecht, Netherlands
TELEPHONE 030-930947

WANG PACIFIC LTD.
61, King Yip Street, 1st Floor
Kwun Tong, Kowloon, Hong Kong
TELEPHONE 3-434231/2

WANG INDUSTRIAL CO., LTD.
110-118 Kuang-Fu N. Rd.
Taipei, Taiwan
Republic of China
TELEPHONE 784181-3

WANG GESELLSCHAFT MBH
Grinzinger Allee 16
1190 Vienna 19
Austria
TELEPHONE (0222) 32.42.43

WANG COMPUTER PTY. LTD.
25 Bridge Street
Pymble, NSW 2073
Australia
TELEPHONE 449-6388

WANG INTERNATIONAL TRADE, INC.
836 North Street
Tewksbury, Massachusetts 01876
TELEPHONE (617) 851-4111
TWX 710-343-6769
TELEX 94-7421

PHI COMPUTER SERVICES
836 North Street
Tewksbury, Massachusetts 01876
TELEPHONE (617) 851-4111
TWX 710-343-6769
TELEX 94-7421

24 Mill Street
Arlington, Massachusetts 02174
TELEPHONE (617) 648-8550

WANG LABORATORIES, INC.
836 NORTH STREET, TEWKSBURY, MASSACHUSETTS 01876, TEL (617) 851-4111, TWX 710 343-6769, TELEX 94-7421

Printed in U.S.A.
700-3120
7-73-1.5M
Volume Price: $25.00
Package Price: $250.00